MAG
Park and Ride Study

Literature Review and Other Research

Final Report

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prepared for:

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Phoenix, Arizona

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LITERATURE REVIEW AND OTHER RESEARCH

Introduction

The Maricopa region is one of the fastest growing major urban areas in the United States. Desert land is being converted into urban, suburban and exurban developments at a rapid rate. Freeway construction is occurring at a pace unheard of elsewhere in the country, but basically represents the completion of the basic regional freeway plan released in 1960. Other cities completed their initial freeway plans a decade or more ago. Valley Metro and the local city bus operators have implemented a base level of transit service, with some peak hour orientation. Yet, the percent of work trips taken by transit is less than 2%, the lowest of any major metropolitan area in the U.S.

This paper sets out to accomplish several points. First, it is intended to document what makes a successful park-and-ride lot. Second, it documents what facilities and services are currently provided and are proposed in the study area (Maricopa) that can provide incentives to park-and-ride lot users (HOV lanes, new freeway segments, new access ramps, travel service plans, existing small park-and-ride facilities, etc.). Next, it presents information on the various park-and-ride lot demand forecasting techniques and presents a recommended approach to such forecasting. Finally, it includes the initial elements of a National Environmental Policy Act (NEPA) Purpose and Need Statement that can be used by jurisdictions later in this project to initiate the environmental review process (See Appendix A). Park-and-ride projects funded with federal dollars (Federal Transit Administration or Federal Highways Administration funding) require NEPA compliance (see NEPA 42 U.S.C. 4321-4346 an amended, as well as TEA-21 legislation).

The intent of this task effort is to provide the information needed to develop criteria on which to make recommendations on both target areas and specific sites during later phases of this overall project. While this report is a good summary source of information on the topics discussed above, its real intent is to provide information for tasks to be conducted later in this study.

Section 1 - Documentation of characteristics of successful park-and-ride lots

This section reviews the pertinent literature on factors that contribute to a successful park-and-ride lot (success defined as attracting the expected number of riders). The literature review of national experience has been supplemented with a survey of transit agencies acknowledged to have successful park-and-ride lot programs in the western United States, namely Seattle, Portland, Denver and Houston. Available information on the two permanent park-and-ride facilities in the Phoenix area has also been included for comparative information.

The factors discussed below constitute the major criteria used by transit agencies to site park-and-ride facilities and are included in the target area and/or site-specific criteria proposed for this project. (Target area and site-specific criteria for this study are included in the Task 3 report.)

In addition to the characteristics discussed below, there are other components of park-and-ride lots that must be considered in the design and implementation phases of a project. Supporting facilities, security issues and access issues (for drive, bicycle and walk modes) will be discussed in the Design Standards working paper developed under Task 3. Operations and maintenance practices and costs will be discussed in the Task 7 working paper.

Location

The real estate adage – location, location, location – applies equally well to transit facilities, and especially so for park-and-ride lots. Transit riders who use park-and-ride facilities usually have other options available to them. They clearly have automobiles and have the options of driving to their destination rather than taking the bus. Thus, ease of access to the park-and-ride facility, the visibility of the park-and-ride lot as an initial attraction to use, and the visibility of the lot from adjacent properties to increase the sense of security and safety are all important locational issues. Location is also critical in terms of proximity to freeways, HOV facilities, and congestion points on the regional road network.

The literature indicates that park-and-ride lots should be located at least 4 to 5 miles and, preferably, ten or more miles, from the major destination.[1] This often allows the transit portion of the trip to comprise 50% or more of the total travel time, considered by some to be an important service element (see discussion below under Transit Travel Time). It also will usually result in a park-and-ride lot being located prior to the point of freeway congestion (or at least not after the point of congestion). Locations further than 30 miles from a destination have not generally proven successful, unless a strong city-pair relation exists (Tacoma to Seattle, for instance).

The proximity of lots to one another is also an important consideration. If demand warrants, based on the experience of a full lot, then another lot serving generally the same market area may also do well and may result in added frequencies of service to both facilities, further increasing demand. On the other hand, a lot with capacity to spare would not likely do better with another lot in the same general area. The demand discussion that follows in the Transit Service section indicates that park-and-ride lots attract most of their ridership within 2.5 miles. Thus, lots located within five miles of each other may be competitive with one another if demand does not justify the additional capacity.

Transit Service

The second critical component is the type and level of transit service available at a given lot. Since park-and-ride users are not a captive market but an attraction market, the transit service itself must be attractive to the potential user. The elements of transit service include:

- Travel time from lot to destination, especially compared to an in-vehicle trip

[1]Park-and-ride Planning and Design Guidelines, Parsons Brinkerhoff Quade & Douglas, Inc., October 1997, p. 34.

- Frequency of service (important if one "just misses" the bus and must wait for the next)

- Span of service (over how long a period is peak express service available).

- Availability of off-peak service (in case of emergency, working late, etc.)

Travel Time

Transit service between the park-and-ride lot and the major regional destination should be as direct as possible, unless a less direct route actually improves overall travel time. Transit routings that can utilize HOV access ramps and HOV lanes not available to the single occupant vehicle are also critical to offering a competitive travel time for the rider. The literature does not indicate a particular difference in total travel time via express bus versus total travel time by private vehicle that will still attract commuters to an express bus trip. With access ramps and HOV lanes through congestion points on the regional network, bus travel times can be competitive or, potentially, even quicker than for an auto-only trip. A study of park-and-ride facilities in Calgary, Alberta, indicates that the total transit travel time for a home to work/school trip should be at least 50% of the total travel time (including auto access to lot and walk access to final destination).[2] This is consistent with the view that if a person is already in their car and has traveled a good portion of the way already, the incentive to change modes is greatly lessened.

Other elements that come into play include the convenience factor (which can work both ways – having a car midday can be an inconvenience; using the bus creates an opportunity to read or snooze), total travel time (an extra ten minutes is important for a twenty minute trip; less so for an hour trip), and proximity of both the park-and-ride lot and the destination transit service to the points of origin and destination. Out-of-direction travel has a perception attached to it of wasted time, whether real or imagined.

Frequency of Service

Concerning frequency of service, the few studies that have been done on park-and-ride lots indicate that service every fifteen minutes is considered attractive to potential users.[3] That is to say, if one just misses a bus, a wait of no more than fifteen minutes will probably keep the rider from getting back in their car and driving to work. Over time, as demand increases at a facility, frequencies can be further improved to less than ten minutes. One park-and-ride

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[2] Planning of Park-and-ride Facilities for the Calgary Light Rail Transit System, prepared by Dan Bodler, et. al. May, 1992.

[3] Studies completed by the Texas Transportation Institute, Texas State Department of Highways, Public Transportation Cooperative Research, and Parsons Brinkerhoff Quade & Douglas on behalf of King County Metro, Federal Highway Administration and others and as references in "Park-and-ride Planning and Design Guidelines," Parsons Brinkerhoff Quade & Douglas, October 1998, p. 24.

report indicates that “further demand will be drawn to the high frequency of service provided at the lot, and demand growth accelerates rapidly.”[4]

Span of Service

The greater the span of express service, the more attractive a lot will be considered by users. With changes in the workplace such as flextime, a tendency toward longer hours and the tendency of employees not to leave the office at the same time everyday, the availability of express service over a long period of time is a major attraction. The literature again indicates that a 3 to 4 hour span in the morning and evening (often longer in the evening than the morning) is optimal.[5] The RPTA’s express bus service guidelines propose a three hour span in both morning and afternoon.

Demand

One service element is whether potential riders are traveling from point A to point B. High frequencies, long service spans, and competitive travel times are of little value if no one is traveling between the origin and destination. Thus, the demand estimating component of the target area analysis is an important consideration in determining whether demand exists for the proposed facility.

Fifty percent (50%) of demand for a park-and-ride facility is likely to be generated within a 2.5 mile radius of a site. An additional thirty-five percent (35%) comes from up to ten miles upstream of a facility (upstream indicating in the opposite direction of the destination from the park-and-ride lot).[6] Again, out-of-direction travel is generally not conducive to park-and-ride demand.

Intermodal Connections

Park-and-ride facilities that serve more than one function often are more successful than a single function facility. Thus, co-locating a park-and-ride lot with a transit center increases destination options for potential users, facilitates transfers among bus routes for other patrons, and generally increases the activity level at a location. Transit hubs also tend to have better all day service levels and a greater span of service than park-and-ride lots served only by express bus routes. The inclusion of vanpool and carpool parking at a lot is important as well.

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[4] Houston METRO, as quoted in “Park-and-ride Planning and Design Guidelines,” Parsons Brinkerhoff Quade & Douglas, October 1998, p. 35.

[5] Parson Brinkerhoff Study, op.cit., p. 35.

[6] Ibid., p. 35.

Costs

As with any transit service, the cost to the user of the transit component is an important consideration. With park-and-ride lots, a major incentive to the user is the lack of parking fees at the lot. (It should be noted that some properties to charge park-and-ride lot users a small fee - usually $1 or $2 - but usually provide a special service as well, such as an all-day security presence at the site.)

Express bus demand is highly dependent on parking fees at the destination point. With day rates ranging upward of $8 a day in downtown Seattle, downtown Bellevue (a Seattle suburb), and the University District north of downtown Seattle, regional express routes tend to do quite well. Ridership to other employment centers, such as a Microsoft campus in Redmond, are less productive, since free parking is provided (though Microsoft does provide free transit passes to those who request them). A commuter trip reduction act in Washington State has required many employers to provide some incentives for transit and ridesharing, as well as imposing parking lot fees for those employees who continue to choose the auto mode. Similar parking rates in downtown Portland and Denver also act as an incentive for transit usage.

Comparative Information from Phoenix, Seattle, Portland, Denver and Houston

Information on size, utilization, access and service characteristics of existing park-and-ride facilities has been gathered from a number of transit agencies. This data is presented in Table 5 at the end of this section. The information covers a wide range of park-and-ride lot types, from small to large capacity, close-in and more remote, and with high levels of express transit service and with limited service, among other characteristics. In addition, system maps (Maps 1, 2, 3 and 4) showing the location of park-and-ride lots in Seattle, Portland, Denver and Houston are also included at the end of this section to convey a concept of a system approach to park-and-ride lot development.

Detailed information is presented on those factors that are of importance in siting a new park-and-ride lot facility. Information was not available on a number of other variables, such as park-and-ride lot usage by time of day, day of week, or month of year. Agencies collect their data is a variety of ways, ranging from monthly, quarterly or even annual counts. Since park-and-ride lots are designed primarily to serve peak hour commuters (to work or education destinations), evening and weekend counts would be of no appreciable value. It is not uncommon for a private operator to arrange with the park-and-ride lot owner to pick up charter groups at lots on weekends, which may result in some usage of the lots during such times; but this would have no bearing on the design size of the facility.

Most counts are done after the morning rush hour and prior to the beginning of the evening rush hour (late morning is most typical). This is the time of greatest usage with commuters having already reached their destination, college students in classes and persons with other types of professional appointments likely to have already headed in toward the region's major destinations. There is some seasonal variation in park-and-ride lot usage, with summers experiencing the lowest demand (fewer college students, workers on vacation, etc.). The counts presented in the tables that follow reflect either annual averages or a spring or fall month or quarter to give the most representative (and highest) count.

Information on maintenance and operating costs will be presented in a separate working paper prepared under Task 7 of this study. Capital costs, to the extent that they are available, will also be presented in the Task 7 report.

Summary Data

Four summary tables have been prepared to summarize some of the more pertinent data gleaned from an initial analysis of the comparative data. Table 1 looks at the size of lots in terms of parking stall availability. About 40% of the lots are in the 300 – 499 stall range, which also shows the highest utilization rate. It should be noted that nearly all of the very large lots (1000 or more stalls) are in the Houston area (two in Metropolitan Denver).

Table 1: Park-and-ride Lot Stall Counts

		Utilization Rate				
	Total Lots	Seattle Area	Portland Area	Denver Area	Houston Area	Average*
<300 stalls	12	89%	37%	69%	--	70%
300 – 499 stalls	34	78%	86%	78%	--	80%
500 – 749 stalls	15	77%	65%	91%	--	79%
750 – 999 stalls	6	106%	100%	--	34%	49%
1000 or more stalls	18	--	--	84%	51%	56%

Source: Park-and-ride counts from RPTA (Phoenix area), King County Metro, Portland Tri-Met, Denver RTD and Houston Metro.

*average includes Phoenix lots

Table 2 summarizes park-and-ride lot locations relative to nearby freeway facilities. Nearly 75% of the lots are adjacent either to freeways or to light rail lines, with an additional 22% located within one mile of a freeway. Utilization rates have also been summarized by proximity, though the sample size of lots 2 or more miles from a freeway is too small to provide any valid comparisons. It should be noted that the main express bus routes at several lots in the greater Seattle area do not use the adjacent freeways due to lack of HOV facilities. Rather, they travel via local arterials to other freeways that do have HOV lanes in order to offer competitive travel times and better schedule reliability.

The data in Table 3 appears to indicate that distance from a park-and-ride lot to the major destination point is not always a major indicator of park-and-ride lot success, even though the national literature states otherwise. A plurality (45%) of lots is located 10 to 14 miles from central cities; an additional 23-29% is located 5 to 9 or more than 15 miles from downtown. The two lots within five miles of downtown are both in the Denver area and have direct access to a light rail system. However, as noted previously, lots too close to major destinations provide little incentive generally for drivers to switch to transit.

Table 2: Park-and-ride Lot Proximity to Freeway

		Utilization Rate				
	Total Lots	Seattle Area	Portland Area	Denver Area	Houston Area	Average*
Adjacent to freeway	39	92%	95%	80%	50%	62%
< 1 mile to freeway	25	76%	40%	--	50%	65%
2 miles to freeway	2	--	--	34%	14%	24%
3 or 4 miles to freeway	3	59%	--	--	--	59%
Adjacent to major arterial	1	--	--	68%	--	68%
Adjacent to light rail line	16	--	76%	101%	--	79%

Source: Park-and-ride counts from RPTA (Phoenix area), King County Metro, Portland Tri-Met, Denver RTD and Houston Metro.

*average includes Phoenix lots

Table 3: Park-and-ride Lot Distance from Central Business District

		Utilization Rate				
	Total Lots	Seattle Area	Portland Area	Denver Area	Houston Area	Average*
Less than 5 miles	2	--	--	101%	--	101%
5 to 9 miles	20	81%	84%	81%	25%	78%
10 to 14 miles	39	76%	68%	69%	32%	61%
15 miles or more	25	83%	--	88%	73%	79%

Source: Park-and-ride counts from RPTA (Phoenix Area), King County Metro, Portland Tri-Met, Denver RTD and Houston Metro.

*average includes Phoenix lots

The final summary table, Table 4, summarizes express bus service characteristics at park-and-ride facilities. There appears to be a direct correlation between service frequency and utilization, with lots receiving more frequent service doing better than those with less frequency service. The implication of the data in Table 4 is that a higher level of transit service is necessary for a park-and-ride lot to be successful.

Table 4: Park-and-ride Lot Express Service Headways

		Utilization Rate				
	Total Lots	Seattle Area	Portland Area	Denver Area	Houston Area	Average*
< less than 5 minutes	2	98%	--	--	--	98%
5 – 9 minutes	31	90%	77%	93%	80%	85%
10 – 14 minutes	22	96%	74%	68%	55%	73%
15 – 19 minutes	20	69%	--	75%	32%	56%
20 – 29 minutes	7	61%	--	--	--	52%
30 minutes or more	3	27%	--	39%	--	27%

Source: Park-and-ride counts from RPTA (Phoenix Area), King County Metro, Portland Tri-Met, Denver RTD and Houston Metro.

*average includes Phoenix lots

Leased park-and-ride lots

There are no examples of major park-and-ride lots being developed on leased property (other than inter-governmental leases such as between state departments of transportation and local transit operators). Leased lots tend to be smaller facilities. For instance, King County Metro operates service to 71 leased lots with a total of 2,942 spaces, or an average of 41 spaces per leased lot. Only two of the lots have at least 100 stalls. One, at the Renton Boeing plant, has 300 spaces and recently had 276 cars in the lot. The general feeling, however, is that most of the cars parked there are Boeing employees who have chosen to park in that area of the plant, rather than elsewhere in the lot.

An example of an unconventional park-and-ride development is the Renton Highland park-and-ride lot in a Seattle suburb. The lot, with 146 spaces, is adjacent to a church and is located on church property. The church had a large gravel overflow parking lot adjacent to their church complex. Metro entered into an agreement with the church whereby Metro would design and pay for the development of the lot (complete with lighting, drainage, etc.) in return for use of the lot for a typical weekday park-and-ride lot. The church receives evening and weekend use of the lot. Information has been requested from King County Metro on the details of an maintenance and operations agreements covering that facility.

Conclusions

A review of the literature search and the experiences of other transit properties indicates that a successful park-and-ride lot

- has a high level of express bus service (service every 15 minutes or more frequent)
- is located within close proximity of a freeway or light rail line (within 1 mile)
- has access to HOV lanes for at least a portion of the bus trip to the final destination
- has express service available over at least a three hour period in both the morning and evening peak hours;
- is visible from adjacent arterials (from both a marketing and safety standpoint); and
- has parking costs at the destination that are substantially higher than the round trip bus fare.

Distance to downtown or other major employment/education destinations does not appear to be as strong a factor, though there are a few examples of lots closer than 5 miles to downtown. The size of a lot is a factor of demand rather than a determinant of demand.

Table 5: Park-and-ride Lot*** Capacity, Utilization and Access Characteristics

Agency and lot	Acres	Capacity	Stalls per acre	Avg. daily utiliz.	Dist. To CBD (miles)	Express transit headway (In minutes)	HOV Facilities	Freeway Proximity
Phoenix								
79th Avenue	7.5	619	82	16%	8	30	HOV ramp to CBD	adjacent
Deer Valley	6.5	260 + 165^	65	**	14	**	1/3 of trip on I-17	adjacent
Dreamy Draw	6.5	230 + 80^	48	21%	10	20	none	adjacent
Seattle,King County								
Auburn	*	367	*	84%	25	20	last 20 miles	<1 mile
Bear Creek	*	334	*	53%	18	15	1/2 of trip	<1 mile
Bothell	*	230	*	78%	15	15	last 5 miles	<1 mile
Brickyard Rd.	*	247	*	86%	18	15	1/2 of trip	Adjacent
Burien TC	*	403	*	83%	12	8	none	<1 mile
Eastgate	*	678	*	100%	10	8	first 8 miles	Adjacent
Federal Way TC	*	894	*	106%	23	8	regular access	Adjacent
Green Lake	*	471	*	90%	5	8	last 4 miles	Adjacent
Houghton	*	450	*	63%	12	8	first 10 miles	Adjacent
Issaquah	*	401	*	108%	15	12	1/2 of trip	<1 mile
Kent TC	*	729	*	66%	20	12	last 18 miles	<1 mile
Kent/Des Moines	*	384	*	95%	18	12	regular access	Adjacent
Kenmore	*	432	*	84%	12	8	last 5 miles	3 miles
Kingsgate	*	502	*	78%	15	15	first 10 miles	<1 mile
Mercer Island	*	244	*	104%	6	7	first 4 miles	Adjacent
Newport Hills	*	292	*	68%	10	20	first 8 miles	Adjacent
North Shore	*	376	*	27%	12	30	last 5 miles	3 miles
Northgate P&R	*	484	*	96%	8	3	last 7 miles	<1 mile
Northgate TC	*	296	*	101%	7	3	regular access	Adjacent
Olson/Myers	*	562	*	18%	6	25	none	<1 mile
Overlake	*	360	*	69%	12	20	1/2 of trip	<1 mile
Redmond	*	344	*	68%	15	25	1/2 of trip	1 mile
Shoreline	*	400	*	64%	11	15	last 9 miles	1 mile
S. Federal Way	*	520	*	106%	25	12	last 23 miles	<1 mile
South Kirkland	*	603	*	81%	12	8	1/2 of trip	<1 mile
South Renton	*	370	*	100%	12	10	last 8 miles	<1 mile
Star Lake	*	549	*	96%	20	8	regular access	Adjacent
Tukwila	*	307	*	104%	10	10	regular access	Adjacent
Woodinville	*	459	*	58%	18	15	last 5 miles	3 miles
Portland Tri-Met								
181st Ave	2.09	247	118	33%	10	8	none	MAX rail
Barbour Blvd.	*	368	*	100%	6	10	none	adjacent
Beaverton Creek	*	417	*	48%	8	8	none	MAX rail
Cleveland Ave.	2.27	392	173	100%	13	8	none	MAX rail
Elmonica/170th	7.80	435	56	85%	9	10	none	MAX rail
Fair Complex	8.99	396	44	46%	14	10	none	MAX rail

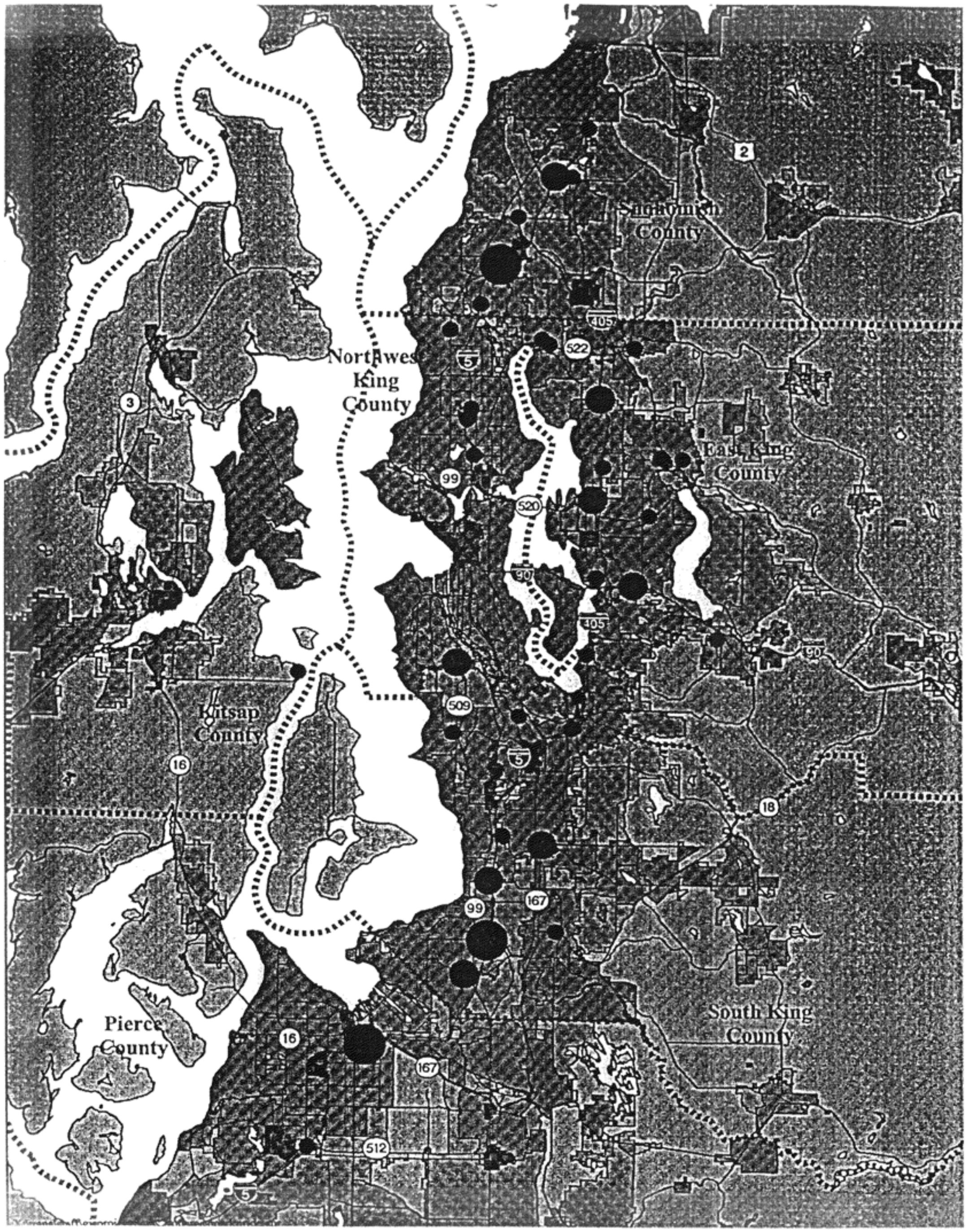
Agency and lot	Acres	Capacity	Stalls per acre	Avg. daily utiliz.	Dist. To CBD (miles)	Express transit headway (In minutes)	HOV Facilities	Freeway Proximity
Gateway	6.60	826	125	100%	5	8	none	MAX rail
Gresham City Hall	3.04	404	133	85%	12	8	none	MAX rail
Gresham Garage	1.68	540	321	45%	13	8	none	MAX rail
Hillsboro Gov. Ctr.	2.98	505	169	53%	16	10	none	MAX rail
Menlo/122nd	4.27	442	104	100%	7	8	none	MAX rail
Millikan Way	8.86	400	45	100%	7	8	none	MAX rail
Mohawk	8.86	232	26	40%	11	5	none	<1 mile
Quatama/205th	4.43	310	70	100%	11	10	none	MAX rail
Sunset TC	6.50	630	97	100%	6	8	none	MAX rail
Tigard	1.96	220	112	40%	8	20	none	adjacent
Tualatin	*	385	*	100%	11	5	none	adjacent
Willow Creek	28.98	595	21	63%	10	10	none	MAX rail
Denver RTD								
I-25 & Broadway	16.8	1003	60	101%	4	5	none	light rail
Alameda Station	4.2	468	111	101%	3	5	none	light rail
Arapahoe	*	358	*	74%	12	15	none	adjacent
Avoca	23.8	284	12	84%	7	15	none	adjacent
Broadway	*	308	*	39%	5	30	regular access	adjacent
Broomfield	59.6	710	12	86%	12	8	regular access	adjacent
Cold Spring	*	423	*	116%	9	10	none	adjacent
Highlands Ranch	*	242	*	85%	18	15	none	adjacent
Nine Mile House	*	420	*	86%	12	15	none	adjacent
Smoky Hill Cutoff	7.2	235	33	34%	9	15	none	2 miles
Southmoor	9.6	497	52	21%	9	10	none	adjacent
Stapleton	*	1115	*	68%	5	local only	none	major arterial
Superior/Louisville	*	306	*	83%	16	8	last 10 miles	adjacent
Table Mesa	*	483	*	98%	20	8	last 10 miles	adjacent
Thornton	*	552	*	88%	8	8	last 6 miles	adjacent
Ward Rd.	9.6	228	24	89%	10	15	none	adjacent
Westminster Ctr.	*	684	*	99%	10	5	regular access	adjacent
Houston Metro								
Addicks	*	2044	*	83%	16	8	access ramp	adjacent
Alief	*	1377	*	14%	14	12	1/2 the trip	2 miles
Bay Area	*	1148	*	61%	16	10	regular access	<1 mile
Eastex	*	930	*	35%	12	15	regular access	<1 mile
Fuqua	*	1381	*	73%	14	11	regular access	<1 mile
Kingsland	*	1310	*	59%	20	11	1/2 the trip	<1 mile
Kingwood	*	1035	*	81%	18	10	1/2 the trip	<1 mile
Kuykendahl	*	2179	*	69%	16	7	access ramp	adjacent
Maxey	*	1129	*	24%	10	16	none	<1 mile
Monroe	*	905	*	29%	10	16	regular access	<1 mile
North Shepherd	*	1605	*	28%	8	17	regular access	<1 mile
Northwest	*	1184	*	96%	20	9	access ramp	adjacent
Pinemont	*	957	*	23%	8	15	access ramp	adjacent
Seton Lake	*	1286	*	43%	14	10	1/2 the trip	adjacent
Spring	*	1266	*	64%	15	12	regular access	<1 mile

Agency and lot	Acres	Capacity	Stalls per acre	Avg. daily utiliz.	Dist. To CBD (miles)	Express transit headway (In minutes)	HOV Facilities	Freeway Proximity
West Bellfort	*	1214	*	75%	15	8	access ramp	adjacent
West Belt	*	1175	*	12%	12	18	regular access	adjacent
West Little York	*	1096	*	20%	12	16	access ramp	adjacent
West Loop	*	1003	*	29%	10	15	1/2 the trip	adjacent
Westwood	*	829	*	50%	12	13	access ramp	adjacent

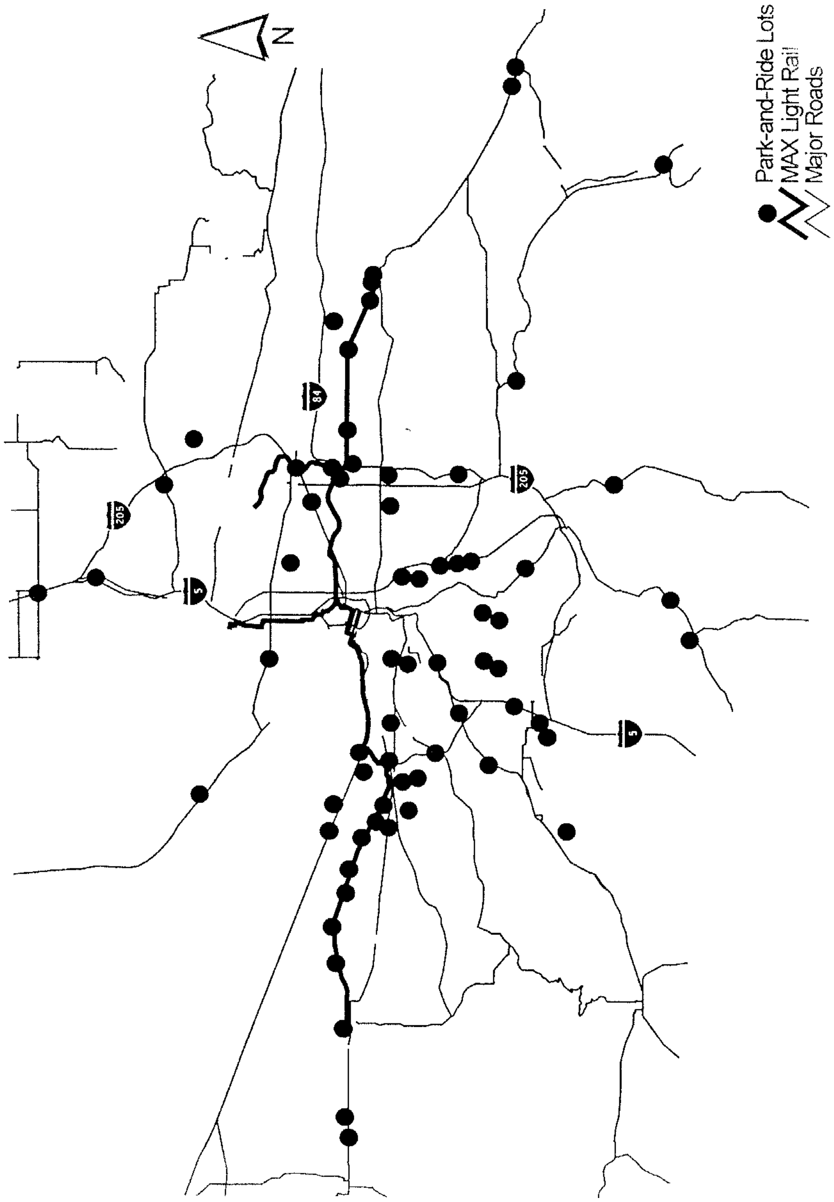
Source: Park-and-ride counts from RPTA (Phoenix Area), King County Metro, Portland Tri-Met, Denver RTD and Houston Metro.

Key:
* - information not available
** - lot scheduled to open April 2000
*** - limited to lots of 200 spaces or more in public ownership or leased by public agency
^ - additional capacity available for expansion

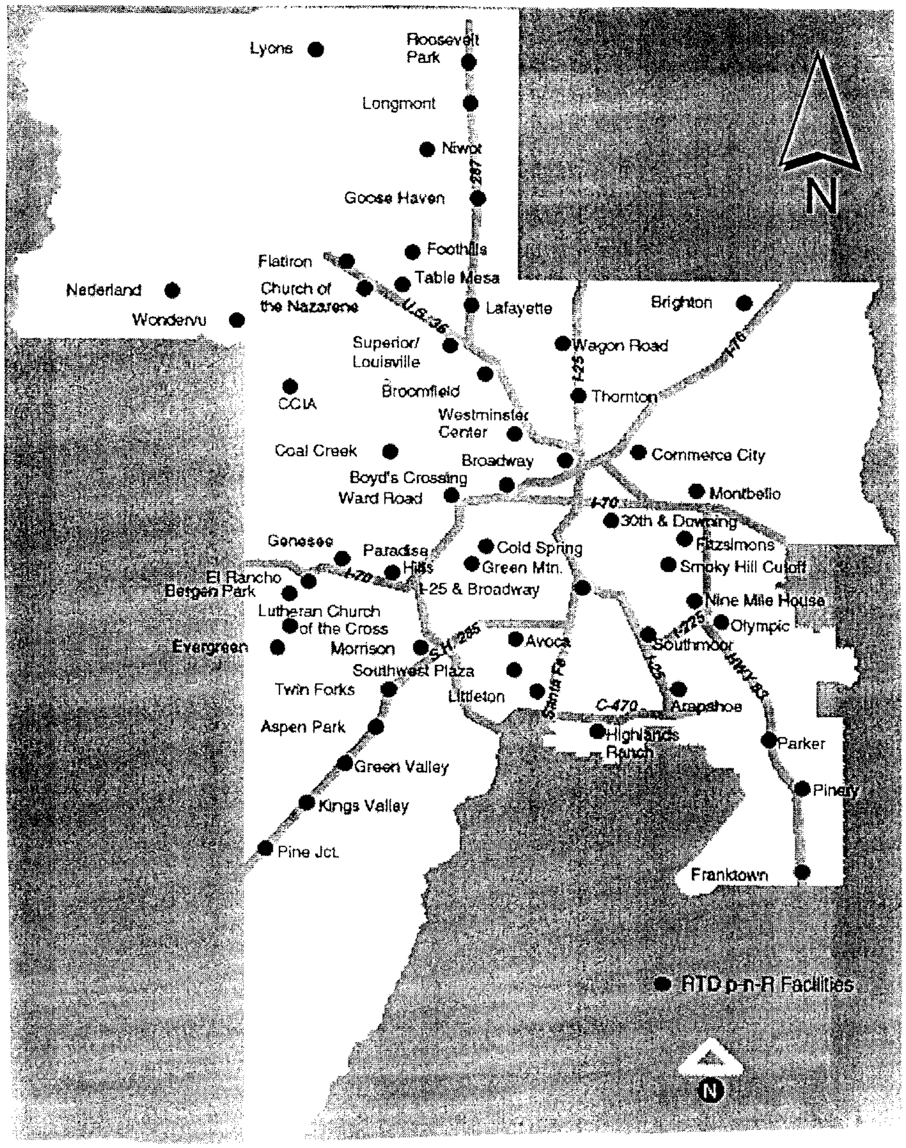
MAP 1 – KING COUNTY METRO PARK-AND-RIDE SYSTEM MAP



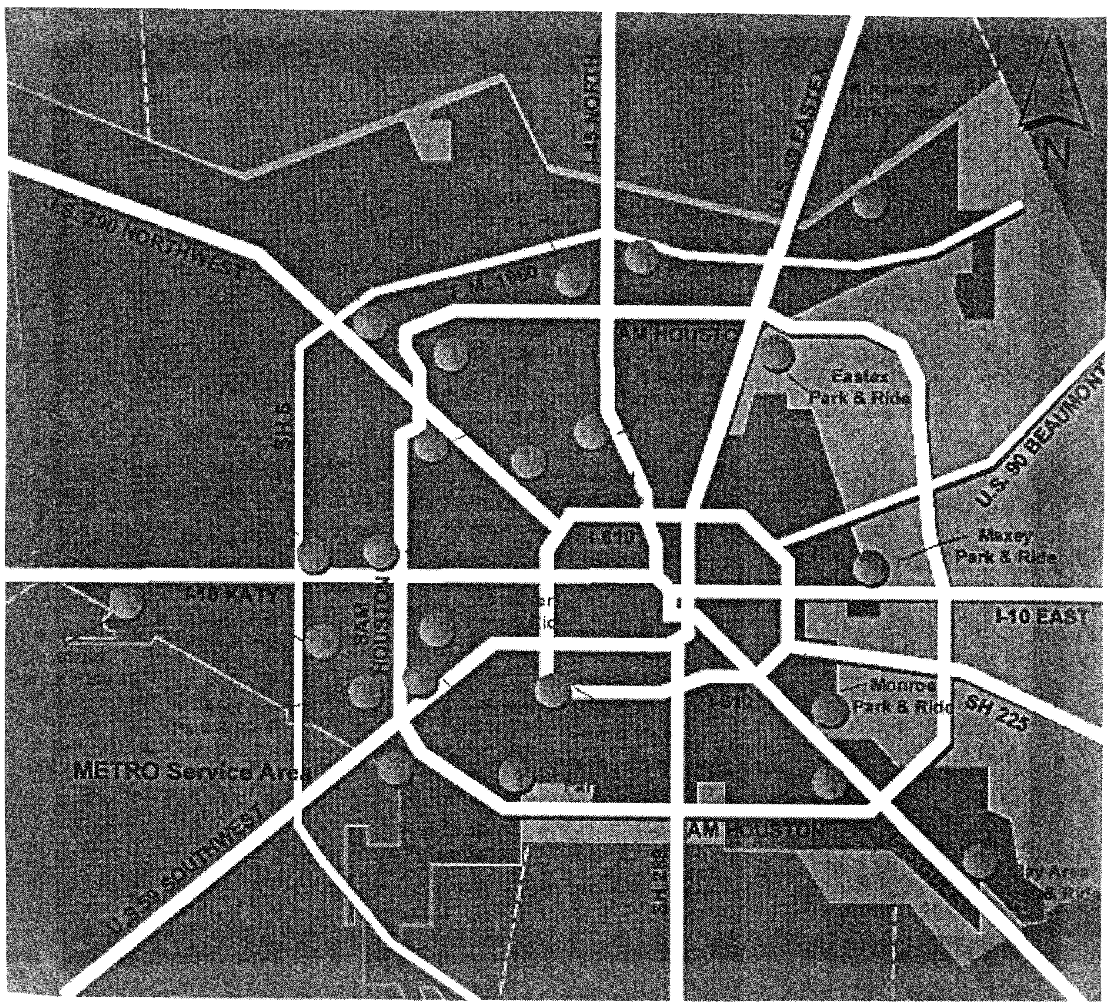
MAP 2 – PORTLAND TRI-MET PARK-AND-RIDE SYSTEM MAP



MAP 3 – DENVER RTD PARK-AND-RIDE SYSTEM MAP



MAP 4 – HOUSTON METRO PARK-AND-RIDE SYSTEM MAP



Success of a park-and-ride system, in terms of utilization, depends in large part on the integration of the lot system with existing and proposed capital facilities and transit services. These facilities and services are a significant determinant of travel times for various travel modes. In turn, the relationship between travel times among the respective modes represents a significant determinant of the demand for the various facilities, including park-and-ride lots. This section documents general use freeways, HOV lanes, existing park-and-ride lots, & transit centers. Since transit is an essential component of a park-and-ride system, express and local bus service has also been accounted for. This section documents existing and planned conditions in the study area based on MAG's Long Range Transportation Plan Update, RPTA's Short Range Transit Plan and Express Bus Study Background Report, the ADOT/MAG/RPTA HOV Facilities Policy Guidelines, the Plan for the MAG Freeway System, and the Valley Metro BusBook.

It should be noted that the information used in the park-and-ride analysis, including the maps, were current in the spring of 2000. Information developed or released later is not reflected in this study or in the information presented on the following pages.

Freeway System

Existing Freeways

Map 5 illustrates the current status of the MAG regional freeway system. The bulk of the freeway network, planned in the 1960's, is scheduled for completion by 2007. Essentially, downtown Phoenix is located at the confluence of three major roadways: I-17 from the north, US60 from the west to east, and I-10 from the west continuing southeast toward Tucson. Additionally, SR51 extends north-south for eight miles just east of downtown Phoenix. Loop 101 operates as a freeway for 16 miles in the northwest quadrant of the region and for 14 miles north-south along the east edge of Scottsdale and along the border of Tempe and Mesa. In 1998, the Bureau of Transportation Statistics (BTS) reported a total of 139 freeway miles in the Phoenix urbanized area constituting 896 total lane-miles of freeway.

The regional freeway plan, originally released in 1960, contained most of the current system including Loop 101, SR 51, and portions of Loop 202 (LRTP 1999 Update, MAG). By 1983, only I-17 and the Maricopa Freeway section of I-10 east of downtown Phoenix were completed. The Papago Freeway section of I-10 west of downtown Phoenix and US60 (Superstition Freeway) east of downtown Phoenix were completed shortly thereafter. However, construction of Loop 101, SR51 and Loop 202 did not begin until the initiation of the ½-cent sales tax approved by the voters in 1985. Since then, the MAG region has been implementing the regional freeway system that many of its peers had already completed.

The 1985 Freeway Plan Update added Loop 202, the Grand Avenue Expressway, and the Estrella Freeway to the regional plan as a result of a half-cent county sales tax. By 1994 portions of SR51, Loop 101, and Loop 202 were completed; however the defeat of another half-cent sales tax increase altered the scope of the regional plan. Most of the 1985 plan has since been restored as a result of increases in committed funding.

Average daily traffic on freeways in the greater Phoenix area is among the heaviest in the nation. In fact, in 1998, only Los Angeles, San Francisco/Oakland, Atlanta, and San Diego experienced more than the average 114,000 vehicles/day on freeways in the Phoenix area. That computes to an average of nearly 18,000 vehicles/day per lane, again one of the highest levels in the nation. In 1998 nearly 30% of total roadway travel in the region was served by freeways which make up only 1.5% of the total miles of roadway in the area. Both values are among the lowest levels in the nation, a result of the extensive arterial grid network that exists throughout the region. Table 6 illustrates the evolution of these freeway statistics as the system has expanded over the last decade.

Table 6. Phoenix area freeway use characteristics in the 1990s

Year	Total Freeway Mileage	Average Daily Freeway Traffic	Total Freeway Lane Mileage	Average Daily Traffic per Lane
1992	113	86,566	671	14,578
1994	115	90,434	679	15,316
1996	132	101,090	824	16,194
1998	139	114,345	896	17,747

Source: Bureau of Transportation Statistics, Highway Statistics

As Table 6 attests, the supply of freeway lanes is not keeping pace with the demand for freeway travel. As a result, several segments of the freeway system currently operate with a P.M. peak period volume/capacity ratio indicative of a level of service F. Map 6 illustrates those areas including most of I-10 between 43rd Ave. and Warner Rd., I-17 from Cactus Rd. to I-10, US60 from Gilbert Rd. to Loop 101, SR51 from Indian Bend Rd. to I-10, and a portion of Loop 202.

Planned Freeways

Funding now available, including new bonding measures and TEA-21, combined with a generally positive economic environment will allow the Maricopa region to complete the system. Map 7 shows approximate routes and anticipated completion dates according to the 1999 Long Range Transportation Plan Update. The connectivity of Loop 101 between I-10 near Avondale to Chandler Blvd. has the highest priority with over $400 million committed according to the 1999 freeway funding plan and completion expected by 2001. Loop 202 has over $1 billion committed to its completion by 2007 from I-10 near the airport to Baseline Rd. in the southwest quadrant of the region. Also, the transition of the Estrella Freeway to multi-lane limited-access expressway facilities is due to begin during the accelerated schedule timeframe and carry through beyond 2007. In addition to new freeways, additional lanes of travel for general use are planned for I-17 between I-10 and Thunderbird Rd. and between Loop 101 and Carefree Highway, for I-10 between Pecos Rd. and Riggs Rd. to the south, and for US60 between Loop 101 and Power Rd., along with several interchange upgrades, ramp renovations, and the construction of collector/distributor lanes. According to the LRTP, the total number of freeway miles in the area is expected to reach 175 miles by the end of 2001 and nearly 200 miles by 2010.

Even with the rapid expansion of the freeway network, MAG traffic model simulations for 2019 using the completed current freeway plan indicate a large percentage of the freeway system is expected to be operating with a volume/capacity ratio above 0.9. Map 8 denotes the location of these lane segments where extreme traffic congestion is anticipated. These segments include most of I-10 from Goodyear to Chandler Blvd., I-17 from Happy Valley Rd. to I-10, US60 from Val Vista to I-10, SR51 from Cactus Rd. to I-10, most of Loop 101 from 59th Ave. in the north to Warner Rd. in the south, and portions of Loop 202. The map clearly demonstrates the need for aggressive travel demand management and/or sharply improved transit capacity to accommodate growth anticipated over the next twenty years.

HOV Facilities

Existing HOV Facilities

The HOV lane made its debut in Maricopa County in 1988 on I-10. According to the MAG Value Lane Study Fact Sheet, there are currently 42 miles of HOV lanes in the MAG region as illustrated by Map 9. Freeway segments with HOV lanes include I-10 from 79th Ave. to Warner Rd., Loop 202 from I-10 to Loop 101, and I-17 from Loop 101 to Dunlap Ave. In addition to travel lanes, other HOV facilities in the region include exclusive HOV freeway connection ramps between I-10 and Loop 202, several HOV ramps along I-10 in downtown Phoenix, and an exclusive HOV ramp at the 79th Avenue Park-and-Ride lot. The lanes operate each weekday morning from 6 to 9 a.m. and each weekday afternoon from 3 to 7pm. The southbound I-17 HOV lane is always in use as an HOV lane.

According to the Value Lane Study Fact Sheet, the region's HOV lanes are capable of moving considerably more people than the general use lanes during peak periods. The Fact Sheet quotes a MAG study that showed that the HOV lane on one freeway segment (I-10 at 39th Avenue) carried 1,000 more persons during the morning peak hour than did the average of any of the three adjacent general purpose lanes.[7]

Planned HOV Facilities

In conjunction with ADOT and RPTA, MAG established a formal HOV plan in 1994. The plan stresses continuity within the freeway system utilizing exclusive HOV lane connection ramps at major freeway intersections. It also includes the concept of an integrated park-and-ride system to ensure travel time advantages for transit users and carpoolers. The plan is currently being updated with the added feature of HOT (High Occupancy Toll) lanes under consideration, allowing single occupant vehicles to use exclusive HOV lanes for a fee.

Map 10 illustrates the MAG HOV plan. The Long Range Transportation Plan includes funding to extend HOV lanes on I-17 from Dunlap Ave. to Thomas Rd., and to construct new lanes on US60 from I-10 to Val Vista and on SR51 from I-10 to Shea Blvd. by 2007. The LRTP also includes funding for HOV freeway connection ramps at the intersection of I-10 and US60 and at the intersection of I-10 and SR51. The HOV plan is expected to be completed sometime after 2007 with the extension of HOV lanes on I-17 between Loop 101 and Thomas Road, on US60 to Loop 202, and on SR51 from Shea Blvd. to Loop 101.

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[7] MAG and ADOT, Fact Sheet – Value Lane Study Looks At Ways to Relieve Growing Traffic Congestion in the Maricopa Region (not dated), p. 3.

The HOV Facilities Policy Guidelines and Plan for the MAG Freeway System Final Report Part II, prepared by Lima & Associates and JHK & Associates, predicts substantial future travel time savings for HOV lane users. The projected savings in 2020 is 17.5 minutes on an average trip in the peak period direction in the HOV lanes on SR51 compared to travel time projections without a HOV system in place. US60 is also identified as a primary beneficiary of HOV lanes with a savings of 13.3 minutes on the average trip due to a low average speed in the general use lanes. These savings are based not only on HOV lanes but also planned freeway lane configurations, the planned light rail line, freeway management system traffic operation improvements and a doubling of current bus coverage. Even when the model accounts for a mode shift to HOV from SOV based on the forecasted travel time savings SR51 and US60 have substantially lower travel times on HOV facilities, 8.8 minutes on SR51 and 9.8 minutes on US60.

Express Bus Service

Existing Express Bus Service

RPTA currently operates twenty-one express bus routes serving Scottsdale, Fountain Hills, Tempe, Mesa, Gilbert, Chandler, Avondale, Glendale, and the North Mountain, Deer Valley, and Paradise Valley areas of Phoenix. The routes vary in number of stops per peak period between two and six resulting in a system-wide average headway of about 30 minutes. In general the routes have a service span of one to two hours during the peak. Map 11 delineates the current express bus routing.

Map 12 shows the location of park-and-ride lots currently in use. Two publicly owned lots, at 79th Ave. on I-10 and at Dreamy Draw on SR51 (at Shea) are utilized by about 150 vehicles per day. Another publicly owned lot at I-17 and Bell Rd. (Deer Valley) is nearing completion, which will bring the total capacity of the three public lots to about 1100 spaces. Four transit centers shown on the map have 354 spaces for park-and-ride and an average daily utilization of 130. Finally, 48 privately owned lots with handshake agreement for park-and-ride use with a total of about 1100 spaces are noted. No formal contract exists between public agencies and lot owners. The most recent report indicates a daily utilization of about 370 or 35 percent for all lots.

According to the RPTA Express Bus Study Background Report published in 1998, through fiscal year 1994-95 express bus ridership has declined an average of about four percent annually since 1990-91. Average daily ridership was at 3534 in 1994-95 down from a pinnacle of 4390 in 1990-91. The most recent statistics from 1997-98 in the RPTA Short Range Transit Plan indicate ridership is leveling off at a current rate of 3574 boardings per day on the twenty-one express bus routes.

In 1995 RPTA conducted an on board origin and destination survey of the entire fixed route bus system. The analysis revealed substantial differences in the ridership profile of express bus users relative to the system overall. Table 7 is a reprint from that study showing differences in age, education, marital status, and household income.

The study also compared the mode used to access bus service. This comparison offers much insight into the socio-economic differences between express bus users and overall system users. Nearly 37 percent of express bus users accessed the transit system by car compared to just 3.6 percent of riders overall. An additional 18 percent of express bus users were dropped off by car compared to just 4.4 percent of riders overall. Two thirds of express bus users had an automobile available to them compared to less than a third of riders overall. These statistics clearly demonstrate the interrelationship between express bus service and park-and-ride.

Table 7. RPTA Bus User Profile Comparison

Characteristic	Express bus user	Overall system user
Average age	*43*	*33*
Average education level	*14.9*	*13.1*
Percent married	*64.7 %*	*31.6 %*
Avg. household income	*$46,200*	*$28,100*

Several other portions of the survey yielded interesting results. Only 13 percent of express bus users were transferring to another route to complete the trip compared to more than a third of overall riders. Nearly all express bus users were making a home-based work or school trip compared to only about a third of overall users. Almost 90 percent of express bus users made the same trip at least four times a week compared to about 63 percent overall users. The analysis clearly demonstrates that the typical express bus user makes routine commute trips usually with no transfer. Almost 62 percent of express bus users traveled less than one mile to access the bus. In most cases express bus service is chosen either despite having access to an automobile or in association with having access to an automobile.

A peer city review conducted by RPTA demonstrated shortcomings of the performance of the express bus system in the Phoenix area relative to ten major western U.S. cities. The review concluded that express bus routes are 40-50 percent longer than typical routes in peer cities. Also, express buses in Phoenix have two to three times more stops than the other systems analyzed. Consequently average travel time in the Phoenix system is 10-15 minutes longer than the comparison cities. Average headways in Phoenix are about twice as long as in the peer cities reviewed and the peak periods served are shorter in span than most peer cities. These factors all help to explain why express bus routes in the Phoenix area have low ridership compared to similar metropolitan areas.

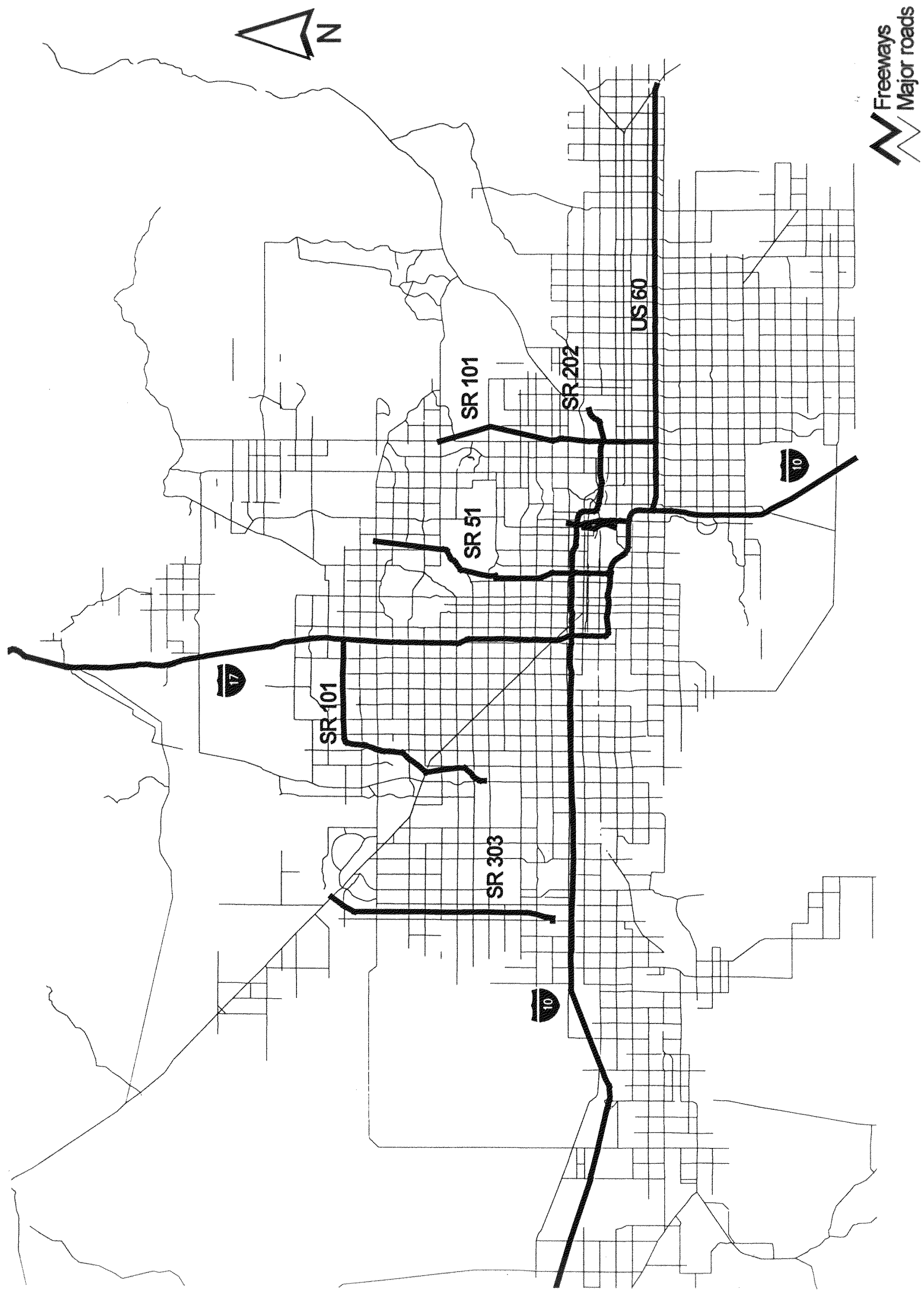
Planned Express Bus Service

The regional LRTP contains an explicit plan to expand the express bus system in the Phoenix area to meet specific service criteria designed to improve ridership. The plan calls for a three hour span of service during the peak periods with headways of 15 minutes. Map 13 illustrates the scope of planned express bus service coverage. The map also shows the suggested location of park-and-ride lots specifically integrated with express bus routes.

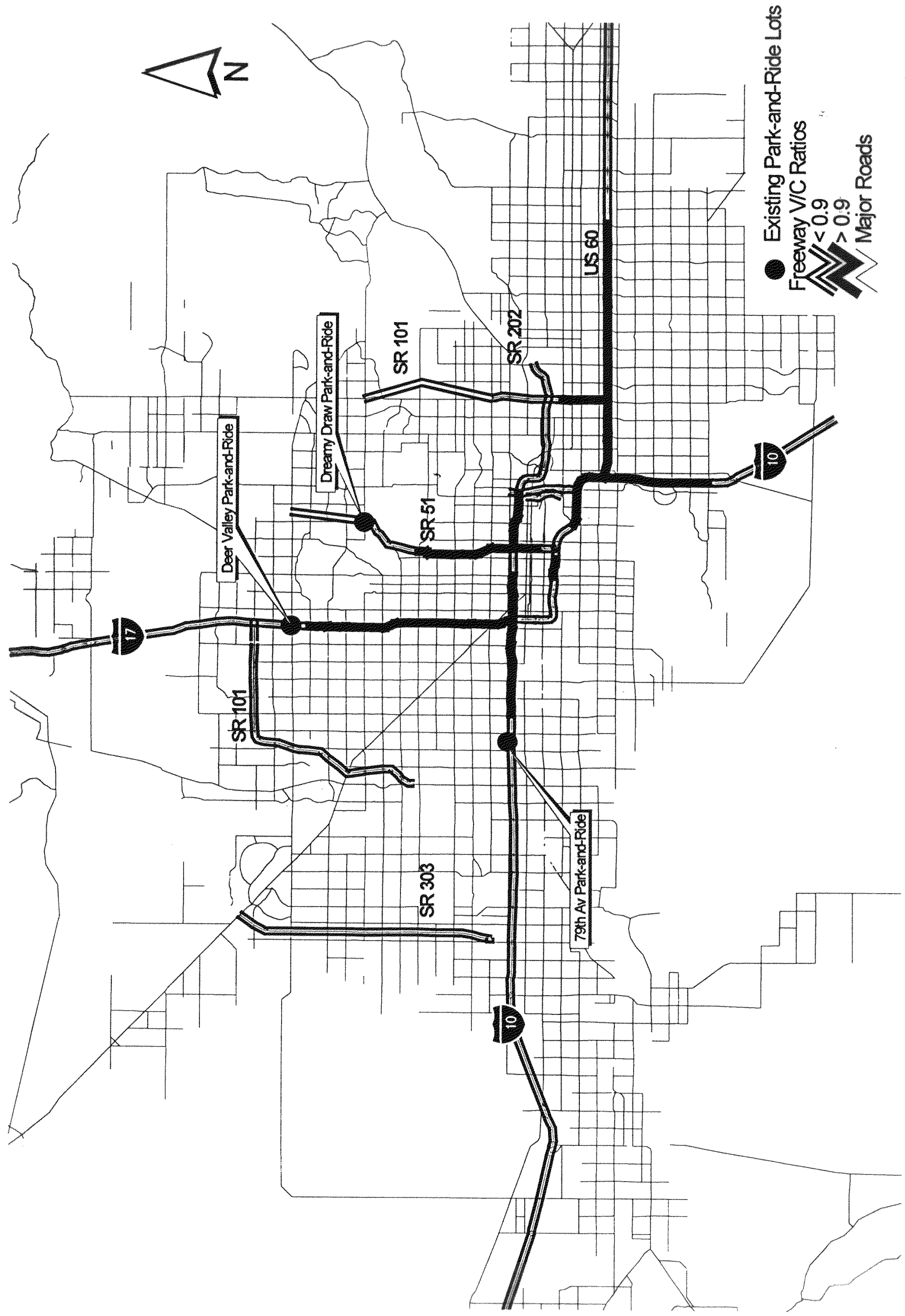
The number of miles covered by express bus service is expected to more than double by 2010 and nearly quadruple by 2020. The LRTP contains a Potential Long Range Transit Funding Plan that forecasts an increase in express bus fare collection from $1.8 million in 1998 to $4.5 million in 2019. Operating costs meanwhile are expected to increase from $4.9 million in 1998 to $18.7 million in 2019. The LRTP suggests that the express bus system will not be provided to areas served by the planned regional light rail line.

In March 2000, voters in the City of Phoenix approved a 4/10 of a percent sales tax to implement Transit 2000, the Phoenix Transit Plan. Four Plan elements have a bearing on park-and-ride lot program. The first is a major increase in express bus service (bus rapid transit). The peak period will expand to 4 hours (5 – 9 a.m. and 3 – 7 p.m.) from the current 60- 90 minutes. Service frequencies will be every 10 to 15 minutes, compared to 30 minutes under current schedules. This service will begin in 2002. The second element consists of capital improvements include signal priority treatments and funds for four new park-and-ride lots. The third component, which will see implementation begin in 2000, is a major expansion of local bus service including service to midnight and 15 minute peak and 30 minute off-peak frequencies. The fourth component is the light rail line linking Chris-town, the Central Avenue corridor, downtown Phoenix and the Sky Harbor airport area. Construction is expected to begin in 2002.

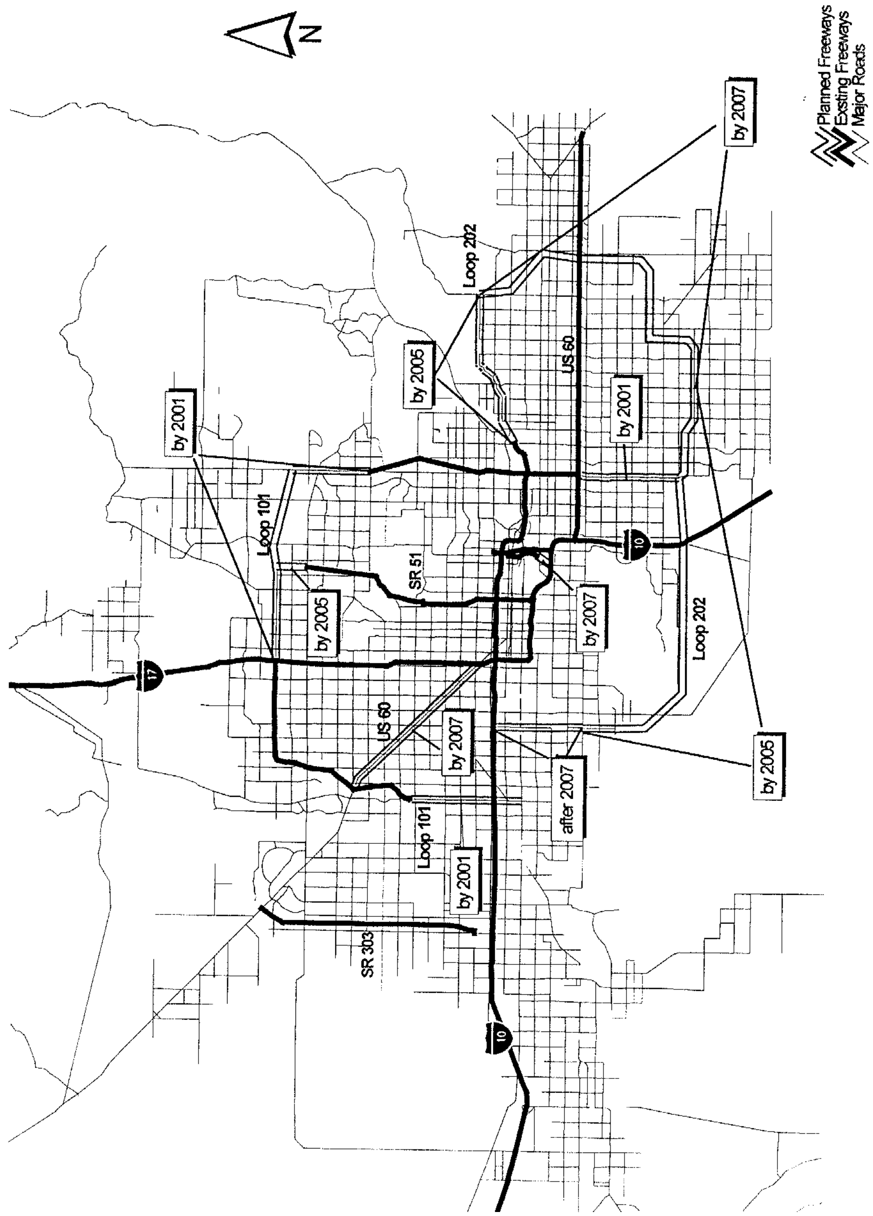
MAP 5 – Existing Freeways



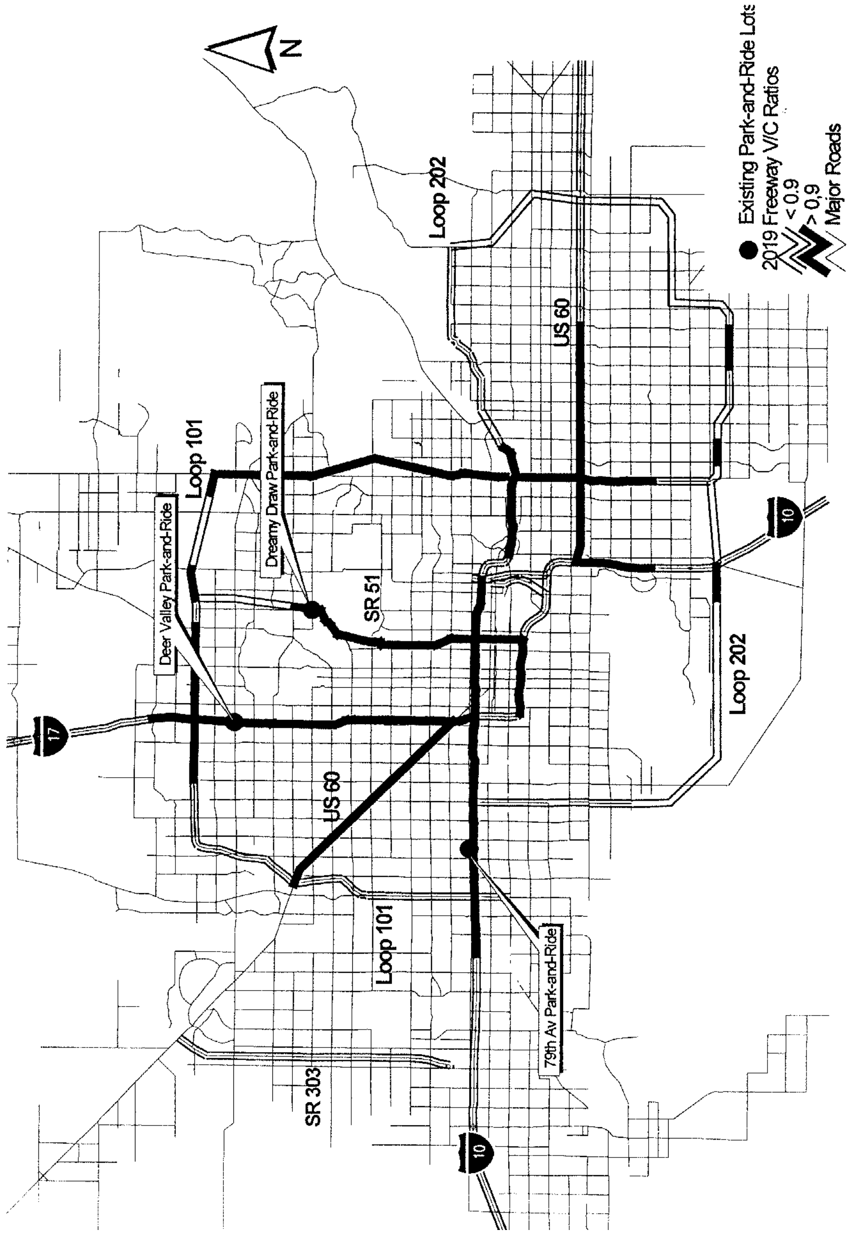
MAP 6 – Congested Freeways (1995 PM Peak Hour)



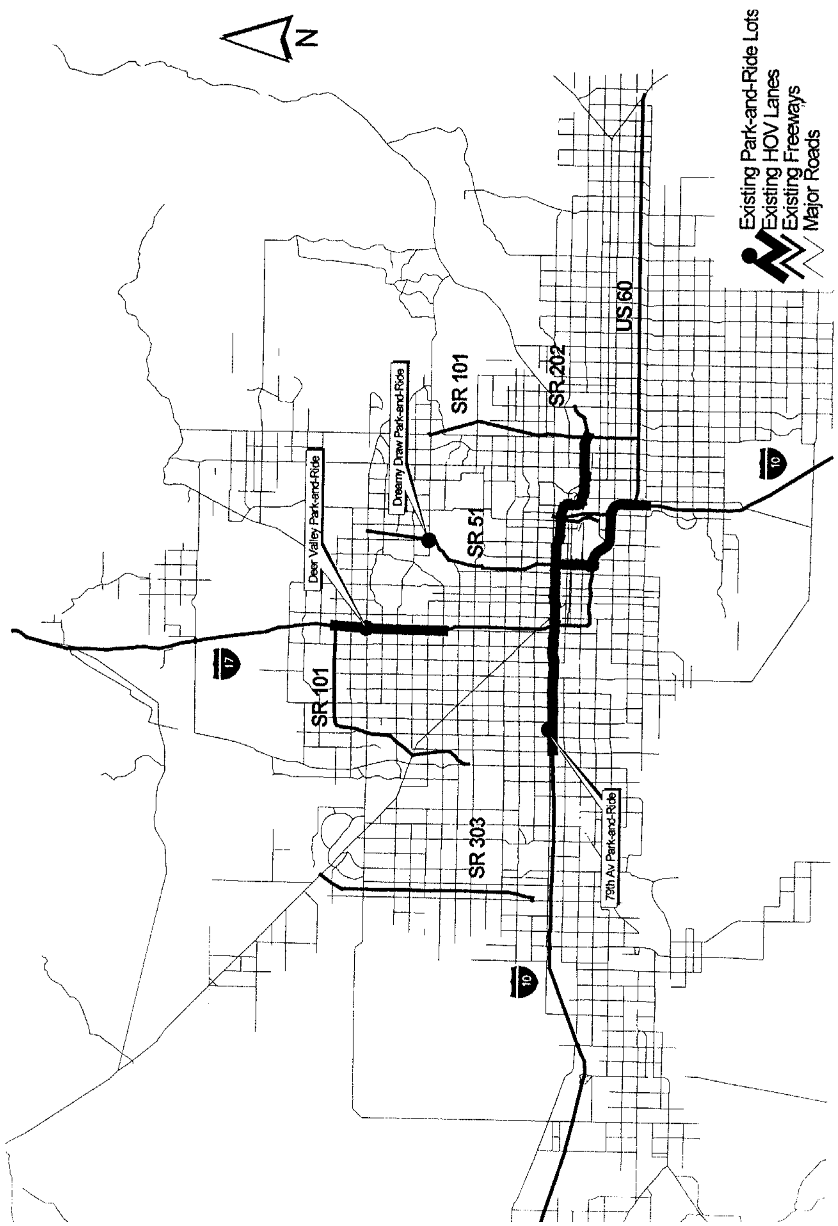
MAP 7 – Planned Freeways



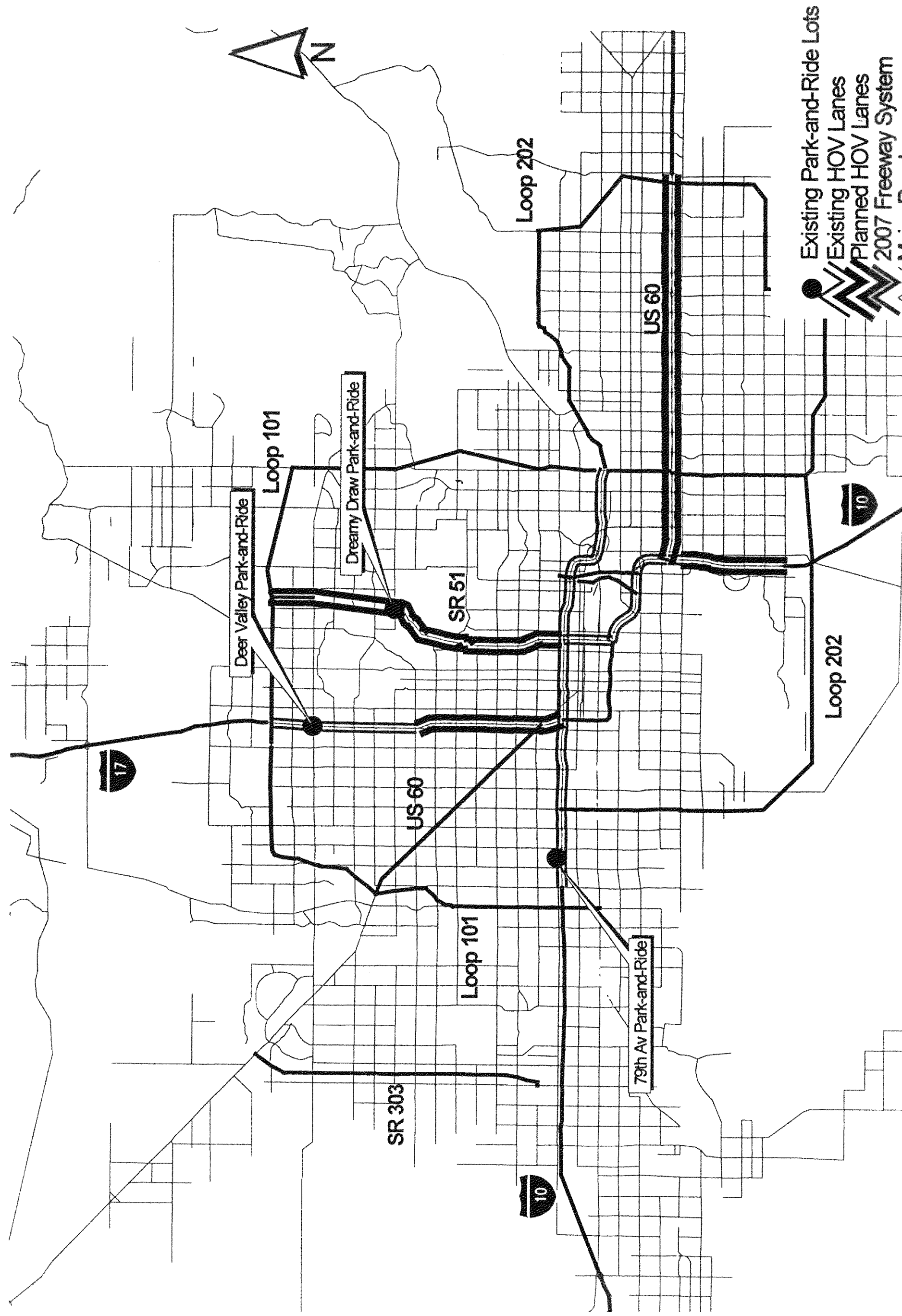
MAP 8 – Congested Freeways (2019 PM Peak Hour)



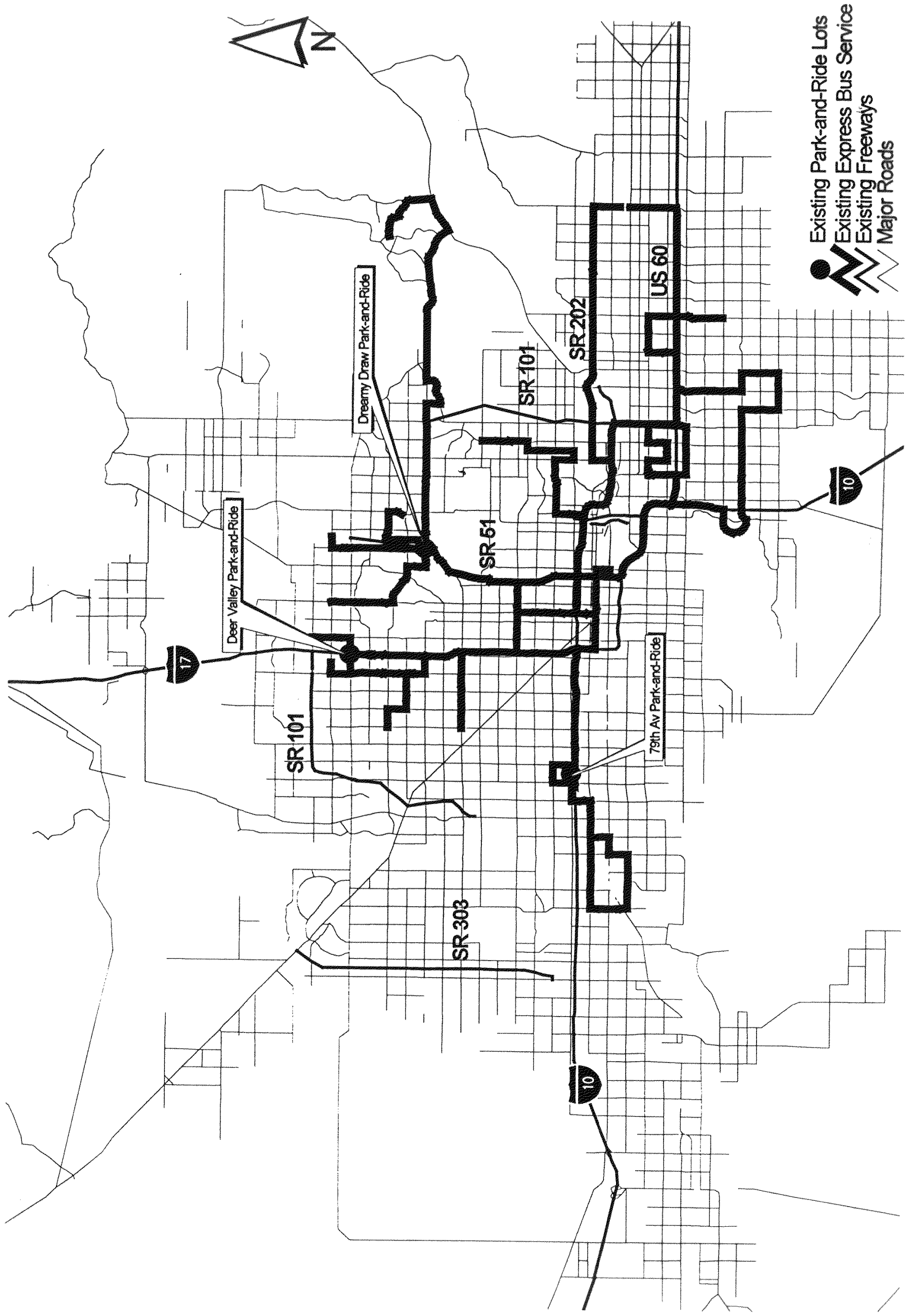
MAP 9 – Existing HOV Lanes



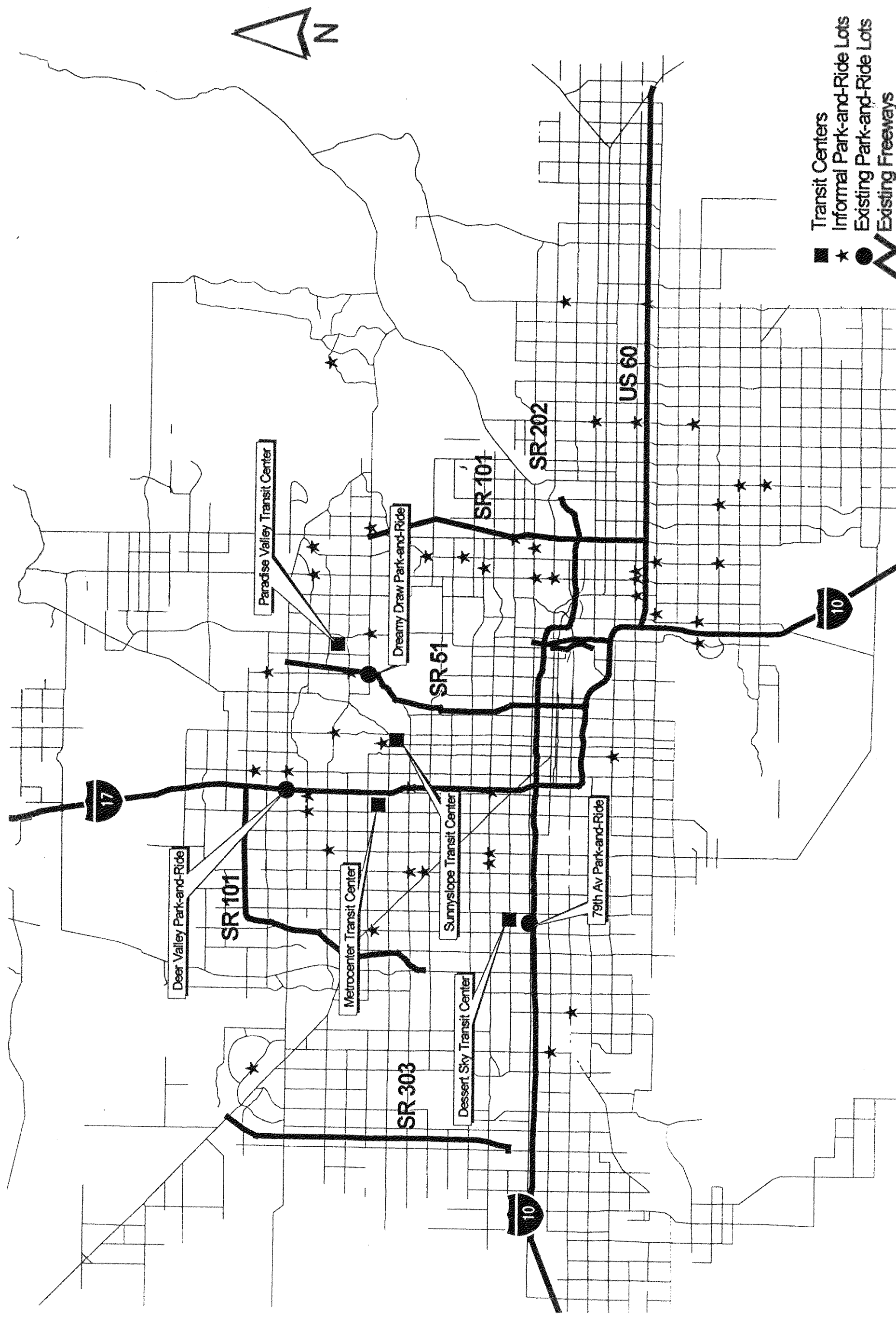
MAP 10 – Planned HOV Lanes



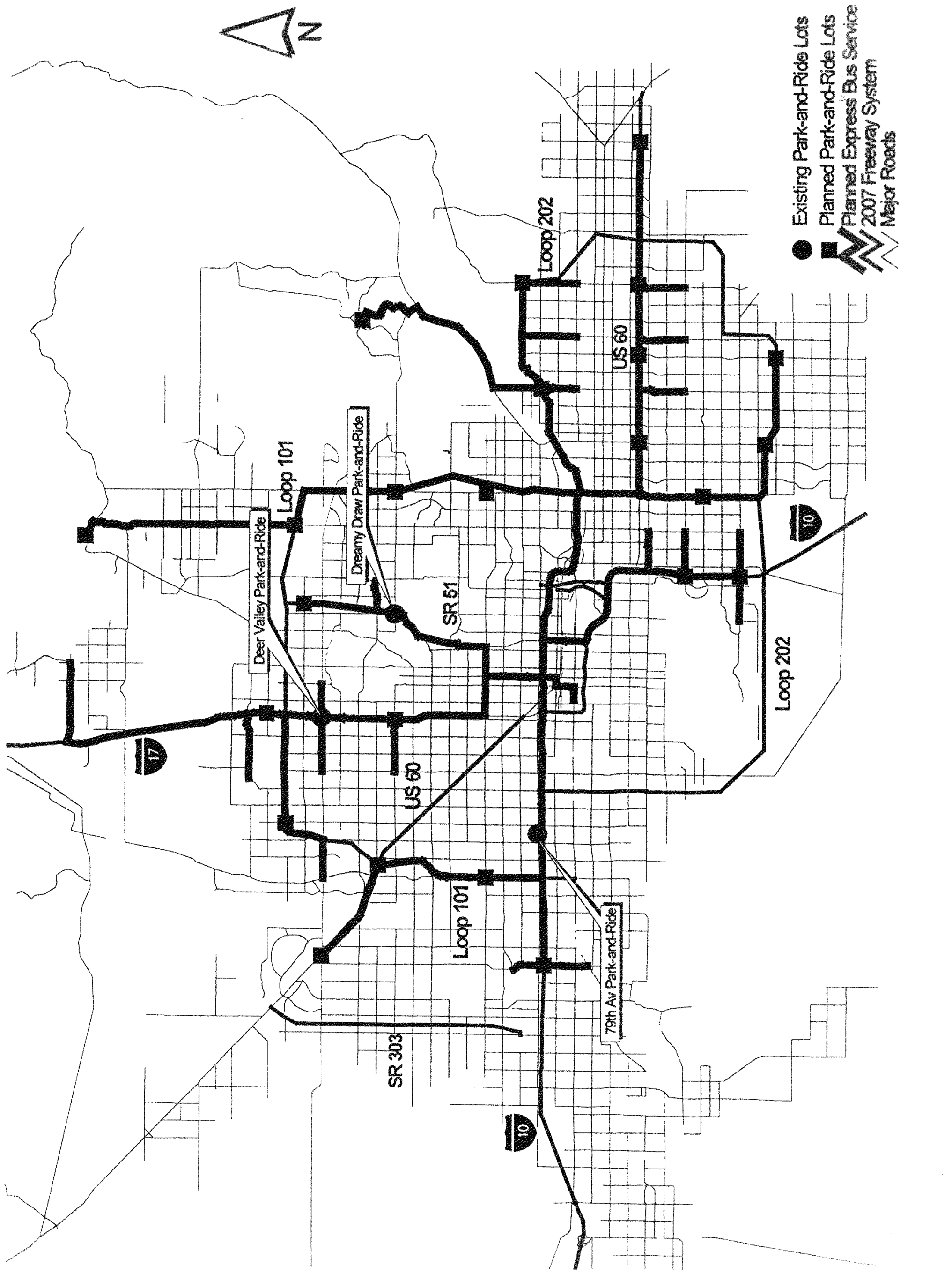
MAP 11 – Existing Express Bus Service



MAP 12 – Existing Park-and-Ride Lots



MAP 13 – Planned Express Bus Service



Section 3 - The Modeling Effort

Part A: Documentation of Park-and-ride Lot Users

Characteristics of Park and Ride Users

A number of surveys of transit users and non-users throughout the US have revealed consistent characteristics of park-and-ride users in major urban areas. KJS reviewed summaries of survey data as well as state-of-the-practice articles related to park-and-ride lots over the past decade. This section summarizes the results of that review and highlights the principal factors influencing their decision to use or not use park-and-ride services.

Table 8: Survey data reviewed

Location and date of survey	Type	Users/ Non-users	No. of responses	Questions asked
Sacramento, CA May 1989	Forms distributed at 32 P&R lots	Users only	264	Origin, destination, mode to/from lot, travel times, reasons for using P&R lot, concerns, attitudes
Northern Virginia 1993	Forms distributed at 26 P&R lots	Users only	2,304	Origin, destination, mode to/from lot, trip purpose, concerns, attitudes, employer type (government, private)
Chicago, Il Fall 1998	Forms distributed at 15 P&R lots	Users only	1,765	Demographics, trip purpose, usage frequency, attitudes, awareness, origin, destination, reasons for using P&R lot
Seattle, Wa 1990	Telephone interviews	Users and non-users	1,233 users 816 non-users	Extensive information covering demographics, attitudes, awareness, trip characteristics and factors for using or not using P&R lots
Phoenix, Az 1995	On-board survey	Users only	12,492	Extensive information of transit riders, not just P&R users
Phoenix, Az ?	On-board passenger survey	Users only	1,526	Origin, destination, access mode, attitudes

Sacramento, CA

This survey by Caltrans of users at 38 park-and-ride lots in the Sacramento region focused on identifying reasons why users chose to use the park-and-ride lots. Lot sizes varied from 10 to 111 spaces, but two-thirds of the lots had between 20 and 40 parking spaces. Only 4 of the 38 lots had transit service, so carpooling and vanpooling accounted for the vast majority of respondents.

Principal findings were:

- 60 percent of respondents lived within 5 miles of the P&R lot.

- 44 to 69 percent of users rode vanpools from the lot, with the most distant lots having the highest vanpool usage.

- Most respondents indicated that saving money in parking costs and long-distance commuter costs as the principal reason for using the P&R lot.

Northern Virginia

The purpose of this survey by Virginia DOT was to provide data for developing a model to forecasts demand for future P&R lots in the Northern Virginia (i.e., suburban Washington DC) region. Surveys were conducted at lots in the I95, I-66 and Dulles Toll Road corridors. No demographic data were gathered, and even the origin/destination information were generalized (i.e., ZIP code level).

Principal findings were:

- 50% of users worked in the DC core, and another 32% worked in Virginia immediately outside the DC boundaries.

- The distribution of users between transit and vanpool varied considerably among P&R lots depending upon the level of corridor bus service, but the percentage of carpoolers were relatively consistent at 22 to 28 percent of all users.

- Vanpools accounted for about 40 percent of users in two corridors, but less than 5 percent in the third corridor (Dulles Toll Road) were transit riders were 70 percent of users.

Chicago, Il

CTA P&R users comprise a small sub-market (less than 0.5% overall) of CTA ridership. The primary purpose of the survey was to identify customer satisfaction with P&R service, and what action CTA could take to enhance P&R ridership.

Principal findings were:

- P&R users were 70% white compared to 48% overall for CTA services.

- P&R users had significantly higher incomes average CTA users ($51,400 versus $33,400), and average auto availability was 2.1 cars for P&R riders compared with 30% of all CTA riders that had no household auto.

- Nearly 90% of P&R users were for work or work-related activities, and on average used P&R 4.25 days in the week before the survey.

- Nearly two-thirds of users learned about their P&R lot by seeing it, and only 7% from advertising.

- Principal reasons for using P&R were travel speed (35% said P&R express bus service was the fastest way to their destination), cost of parking (21%) and because they disliked driving (24%).

- 82% of users were satisfied with their P&R experience, and 92% would continue using their P&R lot in the foreseeable future.

- In regards to amenities at P&R lots, users said they would likely use: fast-food grocery (60%), car wash (48%), dry cleaning (47%), magazine/book stand (45%), bank (43%) and oil change (42%).

Seattle, Washington (Metro)

The King County Metro (Seattle) telephone survey was the only survey readily available that interviewed both users and non-users to distinguish between these two groups.

Principal findings were:

- 96% of P&R users knew the location of the P&R lot closest to their home, as did 74% of non-users; most knew the location from seeing the lot.

- Although most respondents used the P&R lot closest to home, 30% used a lot farther away from home. Of these riders choosing an alternate lot, better transit service (quicker, more frequent, more direct) was the most commonly cited reason.

- Users of P&R lots were three times more likely than non-users to commute to downtown Seattle (66% vs. 21%), and non-users were much more likely than users to commute to outlying employment centers (60% vs. 20%).

- For non-users, 80% traveled to work alone in a car and had travel times about half those of P&R lot users (28 minutes vs. 58 minutes each way).

- For P&R lot users, the vast majority (81%) rode the bus to their destination from the lot, while carpools and vanpools accounted for about 7% each. Nine out of ten P&R users commuting to the CBD rode the bus, while only half or less of P&R commuters to outlying centers chose the bus mode.

- The principal factors influencing the decision to use a P&R lot were: express bus service (53%), cost of parking (52%), frequency of service (44%), and availability of parking at the lot (41%). [Multiple responses allowed]

- For non-users, the factors causing them not to use P&R were: never ride the bus (51%), indirect bus routes (26%), little or no express bus service (21%) and poor schedules (19%).

Phoenix Rider Surveys

Although Phoenix RPTA has not conducted surveys of park-and-ride users, two surveys of riders on express routes and on all routes provide some useful information. The survey of 1,526 express bus riders showed that many of the express bus stops function as park-and-ride facilities without a formal lot, with more than 40% of express riders arriving at their bus stops by driving a car and parking nearby. Another 20% were dropped off at their stop ("Kiss-and-ride"). In follow-on focus groups of area residents (riders and non-riders), participants agreed that convenience for trip making was the principal reason for using or not using express bus service; cost or availability of downtown parking was not a significant factor.

The 1995 Origin and Destination Survey of RPTA riders collected more extensive information on bus riders of all types, both local and express. Some key findings were:

- Median income was $46,700 for express riders compared to $19,500 for local riders.
- Express riders had an average of 1.7 vehicles per household compared to 0.9 vehicles for local riders. Only 19% of express riders were "transit dependent" compared to nearly 80% of local riders.
- Morning express riders most likely drove to a park-and-ride lot (38%) or were dropped off at their stop (18%).
- Express riders used the bus almost exclusively for work trips, and commuted by bus an average of 4.5 days per week.

Summary of Findings

The various surveys of park-and-ride users express bus riders and non-riders described above yield relatively consistent findings about what's important to potential users of park-and-ride lots. Key characteristics of potential park-and-ride users are:

- Park-and-ride users are CHOICE riders; that is, they have other viable travel options available for their trip, but choose to use the P&R service.
- P&R users have significantly higher incomes (1.5 to 2 times the average bus rider) than local bus riders, and almost always have an auto available to make their trip instead of using the bus.
- The majority P&R users (more than 60%) traveled to the CBD for work more than 4 days per week.
- The best advertising for P&R service is high visibility from adjacent freeways and arterials; most P&R users found their lot by seeing it while driving by in their car.
- Carpool and vanpool use of P&R lots can be significant depending upon the location of the specific lot. Transit use is predominately focused on the CBD, while vanpools and carpools use the P&R lots for collection points for trips to outlying employment centers (which typically have less convenient transit service).

The two major reasons for choosing to use (or conversely not to use) park-and-ride or express bus service were:

- Convenience and frequency of bus service to their desired destination.

- Parking cost at destination.

Documentation of traffic and socioeconomic conditions for 1999 and 2020 at the system network and TAZ level.

Upon completion of a thorough review of the MAG model by the consultant team, a brief summary of key data from the model assumptions will be included as Appendix B to this working paper.

Part B: Alternative Methods for Estimating Demand for Park-and-ride lots

Alternative Methods of Park-and-Ride Demand Estimation

Projected base-year and future demand for use of a park-and-ride as a travel option is central both to the facility location decision and site design. Lots should be located to maximize demand in order to optimize the system benefits of park-and-ride utilization. At the site level, anticipated demand determines the necessary capacity of the lot. Underestimating demand can negatively impact adjacent neighborhoods when excess capacity spills onto local streets. It can also become a public relations problem for administrators when constituents are unable to utilize a lot due to insufficient capacity (Metropolitan King County Council News, Metro Online, 10/6/99). Likewise, overestimating demand results in unused capacity appropriately perceived as wasteful public spending.

Demand estimation for park-and-ride facilities does not have a rich history in transportation literature. The simplest approach, described in NCHRP Synthesis 213 (TRB, Katherine F. Turnbull, 1995) would best be described as an heuristic method. This involves integrating a combination of general field observations of traffic conditions, aerial land photos, land use plans, census data, transit patronage statistics, and market surveys into an educated guess for a given scenario. Areas where freeway and arterial traffic along corridors or at major intersections are at or near capacity stand out as good candidates for park-and-ride facilities. Likewise, if a neighborhood has a high level of informal park-and-ride resulting in a large amount of street parking near transit stops, that area would merit consideration for location of a park-and-ride lot. Particularly heavy transit use along certain corridors indicates a potential need for park-and-ride. Census data can be analyzed for information on socio-economic and travel characteristics that correlate with a high degree of demand for park-and-ride facilities. Local telephone or mail surveys can also be implemented to elicit attitudes toward commuting, transit, and park-and-ride to provide insight into demand. Area land use plans are a factor in forecasting future demand for park-and-ride facilities.

A second technique involves a market share analysis. Market areas for park-and-ride lots have been described as circular or as parabolic in shape offset somewhat with the lot oriented closer to the employment center (NCHRP 213). Existing levels of park-and-ride use within the market areas are observed. The modal shares observed are then applied to candidate sites throughout the system. Differences in traffic and economic conditions necessitate subjective tweaking of the estimates. This technique obviously only works when a certain level of park-and-ride facilities exist in a given metropolitan area.

The Institute of Transportation Engineers (ITE) established a method for estimating demand for park-and-ride facilities based on local traffic conditions (NCHRP 213). Measured peak-period traffic flows on roadways near or adjacent to candidate sites are multiplied by an assumed diversion factor to account for part of the estimated demand. This is coupled with results from traffic flow passing directly by the proposed facility adjusted by another diversion factor.

The first attempts at modeling demand for park-and-ride within the context of the regional traffic model have been categorized "post-modeling techniques" and documented in PBQD, 1997. This approach uses output from the traditional four-step traffic model to assign trips to prospective park-and-ride lots. In the initial trip generation step, trip productions and attractions are analyzed for potential trips involving a park-and-ride facility to identify candidate sites. For example, since the predominant trip purpose associated with park-and-ride is the peak period home-based-work commute to a major employment center such as a CBD, zones with high levels of this trip type establish themselves as good candidate target areas. Trip distribution data from the traffic model then determines the number of trips between candidate zones and major employment centers. The third step, modal split, determines the percentage of trips between candidate zones and major employment centers expected to involve access through a park-and-ride either by transit or by carpool. This split can be approximated from the transit and carpool splits in the traffic model and/or by means of a travel survey conducted within candidate zones. The application of the modal splits to the trip distribution table results in the projected capacity needed for a park-and-ride facility.

The State of Florida has published a manual for site selection of park-and-ride facilities that includes a modeling approach that expands on the general "post-modeling approach" (FL DOT Park and Ride Manual). The first step in their approach is to specify the market area surrounding the candidate site. The model employs a formula that outlines the shell of the market area based on travel time to the park-and-ride lot, average speed, and a "circuitry factor" used to transform distance traveled on the road system to an airline (straight line) distance for the purpose of delineating the market area. The next step is to identify trip attraction zones of influence based on their employment concentration. The manual uses a minimum of 10,000 employees per square mile as a target figure to determine which zones to consider as attraction zones in the model. Then the trip volumes between zones with candidate sites and major employment centers are pulled from the regional traffic model.

As in the general approach, the next step is to approximate the modal split using travel times from the traffic model, transit characteristics, and parking costs at the major employment center. Then the methodology requires calculating disutility values for each mode and for each zone of origin as a function of travel time and out-of-pocket costs. A logit model is then applied to the disutilities resulting in a set of probabilities of use for each mode in each zone of origin. The parking requirements for a potential park-and-ride location is then calculated using a formula that accounts for carpooling both to and from the facility.

The Approach Used for Park-and-Ride Demand Estimation

A two-phased approach was used for estimating potential demand for the proposed park-and-ride lots. A generalized measure of park-and-ride demand was first developed for use in evaluating and ranking the initial set of 32 park-and-ride target areas. A refined process, incorporating the effects of planned regional express bus service, was then used to estimate potential demand for specific park-and-ride sites in the 19 target areas which were identified for detailed evaluation in the second phase of the study. Both processes were based on forecasts of year 2020 Home Based Work (HBW) person trips from MAG's regional travel demand models.

Phase I estimates

For the first round of estimating park-and-ride demand, a simplified approach was taken which incorporated year 2020 travel time and person trip forecasts from the MAG regional models. It eliminated the time consuming steps of detailed coding each park-and-ride lot in the regional network, defining transit service for each potential lot, and running the MAG mode split computer model for each of the 32 potential park-and-ride target areas.

The Phase I model used total HBW person trips (all modes) with travel times of 10 minutes or more by auto between origin and destination. The 10-minute travel time cut-off was chosen because short trips were not likely to divert to park-and-ride modes. For purposes of this evaluation, park-and-ride modes included both transit and vanpool or carpool (High Occupancy Vehicle or HOV) trips using the lot as a transfer point. Including HOV as a potential park-and-ride mode allowed the analysts to see if potential lots could serve as consolidation points for longer distance shared-ride trips that did not have sufficient demand to justify fixed-route transit service by 2020.

Each of the 1,541 traffic analysis zones (TAZs) in the MAG regional model was assigned to one of the initial 32 target areas identified in the study. Home Based Work (HBW) person trips by auto and transit trips among these 1,541 TAZs were input to the Phase I model, along with the auto (congested), transit and HOV travel times for each origin-destination (O-D) pair.

The Phase I model assumed that *every* HBW trip maker was a *potential* park-and-ride user, either via transit or car/vanpool (HOV). However, since only "target areas" rather than specific park-and-ride sites were defined for the Phase I analysis, *any* TAZ within a given target area *could* contain a park-and-ride lot in 2020. This procedure obviated the need to specify park-and-ride locations within each target area, although it increased the number of calculations that had to be made with the model. Fortunately, the calculations involved relatively straightforward matrix manipulations of the MAG model data, and they were not nearly as time consuming as running the full MAG mode split model chain 32 times.

For each HBW trip interchange (OD pair) greater than 10 minutes long, the trip was split into two legs: leg 1 was from the origin TAZ to a park-and-ride lot TAZ, leg 2 was from the park-and-ride TAZ to the destination TAZ. The *potential* park-and-ride demand in each TAZ was estimated based on a comparison of the auto, transit and HOV travel times between the initial origin-destination trip and the origin-park-and-ride-destination trip.

The comparison was made using a mathematical formula called a *logit* model which used an exponential function to allocate trips among various choices based on the relative travel times and costs among the choices. In this case, the choice was between using a park-and-ride lot or not, and which park-and-ride lot is chosen, if any, for the trip. The Phase I model reflected travelers' inclination to transfer to transit (or HOV) earlier in the trip, time being equal, rather than driving close to the destination before switching to a bus or car/vanpool.

A weighted average park-and-ride travel time, weighted by the demand at each lot, was calculated for each O-D pair using the auto time to the lot, and the transit/HOV time from the lot plus a fixed 15-minute wait time at the park-and-ride lot. HOV times are travel times for trips that use the HOV priority lanes in the MAG regional 2020 network; transit times incorporate the faster HOV priority lanes where possible. A simplified logit function was used to calculate potential park-and-ride demand using this weighted average travel time compared to the auto drive time. Essentially, if the auto OD travel time was less than the weighted park-and-ride travel time, then park-and-ride trips were assumed to be zero because the park-and-ride offered no advantage over the drive-along choice.

The TAZs were summed for each target area, and the results compared to rank the 32 initial target areas. These rankings were used to help identify the 20 target areas selected for analysis in Phase II of the study.

Phase II estimates

For Phase II, the estimating process incorporated the effects of MAG's funded Express Bus System as coded in their transit network, and reflected the specific locations of potential park-and-ride sites within the 20 target areas analyzed in Phase II. .

For each target area, those express bus routes were identified that could serve lots in the target area. Potential route deviations from the funded Express Bus plan in order to serve candidate sites were identified, ranging from simple on/off routings for routes that pass by a site, to changes in a route's starting point to have it originate at a park-and-ride lot. In many cases, specific candidate sites were located some distance away from a freeway and only one express route would logically serve a given lot. The span of express bus service was assumed to be three hours in both the morning and evening peak periods, except for lots in the City of Phoenix, where a four-hour peak period span was assumed.

Using the Express Bus route information, the park-and-ride demand estimates by target area were reviewed to see if any adjustments were warranted based on the additional information. The 19 target areas selected for Phase II corresponded well to the structure of the Express Bus system, and the transit and HOV travel estimates used in the Phase I model appeared to adequately reflect 2020 conditions at the regional planning level. Therefore, it was decided that not to re-run the time-consuming MAG mode choice models with the Express Bus network but to use a qualitative assessment of transit service and auto accessibility to rank the demand potential of specific park-and-ride candidate sites within each target area.

Each candidate site within a target area was rated on a scale of 0 to 100 percent in its ability to capture the potential park-and-ride demand estimated for the entire target area. This rating was based on the *relative* accessibility of the site via auto using the arterial streets serving the site as well as the *relative* accessibility of the site for Express Bus service to/from the nearest freeway. Centrally located sites adjacent to a freeway interchange were rated at 100 percent, and ratings decreased from that ideal. Duplication of one site's potential service area with a site in another target area was also factored into the rating, with the more attractive of the two given the higher rating. This process did ***not*** include the effects of nearby transit trip generators, such as high-density residential housing, on likely walk-to-transit demand because the study focused on auto-access, park-and-ride demand.

Appendix A

Initial Draft of National Environmental Policy Act (NEPA) Purpose and Need Statement

1.0 Need for and Description of Proposed Action

The development of a regional express bus network, including an integral network of park-and-ride lots, has been in the works for a number of years. In 1994, The Maricopa Association of Governments (MAG) Regional Council approved the report "High Occupancy Vehicle Facilities, Policy Guidelines and Plan for the MAG Freeway Program." The report, prepared for the Arizona Department of Transportation (ADOT), MAG, and the Regional Public Transportation Authority (RPTA), included a network of High Occupancy Vehicle (HOV) lanes, HOV access ramps, and thirty park-and-ride lots.

More recently, the draft MAG Long Range Transportation Plan Summary and 1999 Update and the 1999 Update of the Regional Transit Plan include park-and-ride lots as part of a revised express bus plan. Several other studies and plans by ADOT, MAG, the RPTA and the City of Phoenix have also addressed park-and-ride lots as an integral element of improved public transit services in the Phoenix region.

In 2000, MAG, ADOT, the RPTA and local jurisdictions throughout Maricopa County have been involved in a park-and-ride lot selection study. That study developed criteria for prioritizing the potential target areas for park-and-ride lot development and for identifying and prioritizing specific sites within the recommended target areas for both near-term and long-term park-and-ride lot development.

That study recommended that the area of *[specific freeway and specific interchange]* be included for *[near-term]* park-and-ride lot development as part of the regional express bus system. This recommended site was one of *[five]* carefully examined in the MAG park-and-ride lot selection study, shown in Figure 1. The sites were identified based on several factors including:

- Available land/Capacity and potential for expansion
- Opportunities for Joint Use
- Availability of express transit service
- Vehicle access
- Freeway proximity and access to HOV lanes and ramps
- Location relative to freeway congestion

In evaluating and prioritizing the sites, other factors were also considered including:

- Land Use Compatibility and Regulatory Issues
- Visibility of the site
- Opportunities for joint use
- Security issues
- Vehicular and Non-motorized access
- Potential Design Constraints
- Identification of major environmental issues

- Location relative to freeway congestion
- Land and development cost
- Jurisdictional support
- Community issues
- Projected demand
- Access to HOV facilities

Based on these factors, the *[name of jurisdiction]* has selected site *[A, B, C,…],* shown in Figure 2, for a park-and-ride facility. The proposed action would address the needs listed above and would provide the advantages listed in the following section.

Location

The recommended site, located *[fill in specifics]*, is comprised of approximately *[insert #]* acres of land. The site is owned by *[fill in specific information of both public and private owners including approximate acreage owned by each party if more than one owner]*.

Transit Service

The project area is served *[or is proposed to be served]* by *[#]* express routes and *[#]* local routes. The express routes *[list specific routes if known],* shown in Figure 3, are destined for the *[list major regional destination – Central Avenue Corridor, Downtown Phoenix, Sky Harbor, Downtown Tempe, Scottsdale Air Park]* and *[will]* make a total of *[#]* daily trips to and from the general project area. Express routes *[list specific routes]* access *[list freeway]* from *[list interchange]* while express routes *[list specific routes]* access *[list freeway*] from *[list interchange]*.

[Also discuss location relative to freeway congestion between site and major regional destination.]

Local routes *[list specific routes if known]* would also serve the facility. *[List specific routes, the major corridor served and the major destination or transfer point(s) served. Also list total daily trips. Include Figure showing the local bus routes serving the site.]*

Visibility

[Discuss visibility of site from nearest adjacent arterial; discuss marketing potential, safety and security, proximity to businesses.]

Transit Accessibility

The site location would provide *[excellent]* accessibility for express buses and carpoolers using *[list specific interstate]*. By locating the facility in this area, potential riders are able to park at the site and use express buses which have *[discuss freeway access for buses, including any special HOV access ramps, HOV lanes, etc.]* Local buses would *[describe local bus access to site – whether direct access through lot or service on adjacent arterial; discuss walk distance to site if not within or directly adjacent to site]*.

General Traffic Access

General traffic access to the park-and-ride facility would be from *[name of arterial]*. *[Describe any proposed access route, route restrictions, such as right in, right out, etc.]*

Expandability

[Describe any potential for expansion of the park-and-ride facility; include any discussion of phase construction.]

Joint Use

[If the site is a joint use site, discuss details here. Ownership and current use; compatibility of use with park-and-ride facility, etc.]

Description of Proposed Action

[Continue with remainder of section 1 of the Environmental Assessment]